"Chance favors only the prepared mind."

—PASTEUR

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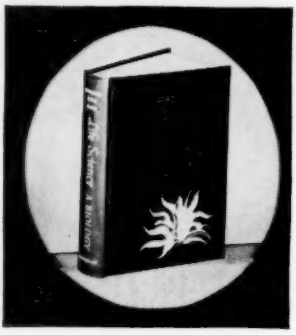

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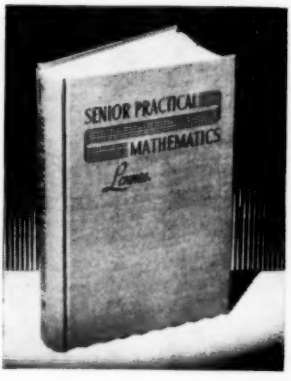

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SCHOOL SCIENCE AND MATHEMATICS

VOL. XLI | OCTOBER, 1941 | WHOLE NO. 360

ATTEND THE 1941 CONVENTION IN CHICAGO

The Central Association of Science and Mathematics Teachers will hold its 41st annual convention in the Stevens Hotel in Chicago on November 21st and 22nd, 1941. It is one of the oldest and most unique educational organizations in the country and holds a place of leadership and high esteem among teachers of science and mathematics.

That the Central Association Convention is regarded highly by experts in the fields of mathematics and science is proven by the prominent individuals who have already agreed to appear on the program. Included are: Dr. Arthur H. Compton, Nobel prize winner and cosmic ray authority; Dr. C. A. Elvehjem, authority in vitamin research and professor of biochemistry at the University of Wisconsin; Dr. J. O. Perrine of the American Telephone and Telegraph Company who will again give the banquet demonstration, this time on the Artificial Creation of Speech; Dr. S. Donald Hudson, authority in conservation, a member of the National Resources Committee, and professor of geography at Northwestern University; Dr. Otis Caldwell, long time member and past president of the Association and prominent in his many scientific pursuits; Dr. H. B. Lewis, professor of biochemistry and authority in foods at the University of Michigan; Dr. K. L. Horovitz, head of the physics department at Purdue; Dr. C. W. Jarvis, professor of physics at Ohio Wesleyan University; Dr. S. R. Powers, head of the bureau of research in science teaching at Columbia University; and Dr. Ira Davis, chairman of the committee developing a program in science teaching and professor at the University of Wisconsin.

Alert, progressive, middle western science and mathematics teachers are now making plans to attend the convention. New

acquaintances and associations will be stimulating; new information on latest developments in the fields of mathematics and science will function in the work of the classroom; seeds of inspiration will be planted which may later flower into achievement in hitherto unexplored fields; and contacts may be made with administrators who are looking for additions to their staffs. The Stevens Hotel affords exceptional opportunity for the display of textbooks and laboratory apparatus and for the conduct of meetings.

A yearbook containing all convention information will be sent to all association members. Others may have a copy on request. I hope to meet you at the convention in November.

HAROLD H. METCALF, *President*

DISPLAY OF THE FLAG

The flag, by universal custom, is displayed on buildings and on stationary flag staffs in the open only in fair weather and only between the hours of sunrise and sunset. It should always be hoisted briskly and lowered slowly and ceremoniously, care being exercised that at no time does it touch the ground. The flag may be carried in a procession or displayed indoors at any time.

When the flag is displayed flat on a wall, either horizontally or vertically the blue field should be in the upper left-hand corner. If suspended vertically over a street the blue field should be to the north or to the east. If suspended from a rope or from a staff out from a building the blue field should be at the peak, that is, farthest from the building. The book, *The Flag of the United States: Its History and Symbolism* gives the following useful rule: "We always speak of the flag as the Stars and Stripes—never as the Stripes and Stars. Therefore, when we look at the flag it should read 'Stars and Stripes'—that is, the stars (in the blue field) should come first.'›

The center position at the front of a parade, float, or automobile is the favored position for the flag. The position next in importance is at the right as viewed from the moving column or from the vehicle. When displayed on a wall behind a speaker the flag should be in the center and above the heads of stage guests and speaker. If displayed on an auditorium stage from a staff, the flag should be at the speaker's right, that is, at the left of the stage as seen by the audience. An effective way of displaying the flag indoors is to play a stream of air on it from a fan concealed in a display of ferns or flowers.

The flag should never be draped. For draping use red, white, and blue bunting. Here, as in displaying the flag, blue is the honor color; consequently, the bunting must always be arranged with the blue on top or at the observer's left, white next, and red below or at the observer's right.—*Prepared by Carl A. Jessen, Senior Specialist in secondary education, U. S. Office of Education, in cooperation with The United States Flag Association.*

HUMANIZING THE TEACHING OF SCIENCE BY USING THE BULLETIN BOARD

JAMES D. TELLER
College of Education, Ohio State University

Great teachers of all ages have utilized many materials and various methods in their attempts to inspire in their pupils a sense of human dignity, to stimulate their imagination, and to broaden their learning. Such teachers have had a humanizing influence on every study which they have used as a means for achieving their goals. However, even a superficial study of the lives and times of great teachers will show that their methods tend to degenerate into a dehumanized routine in the hands of their disciples.

An admirable illustration of this resurgence of formalism which occurs after the work of each great teacher is to be found in that memorable essay of Thomas Henry Huxley on "A Liberal Education and Where To Find It." Here Huxley attacks the gerund-grinding methods of those teachers in England who were despoiling the classical studies of their essential humanism during the third quarter of the nineteenth century. In order to emphasize the futility of such methods, he continues by showing how a scientific study, palaeontology, might be taught so as to rival the dehumanizing methods of the classicists. His famous analogy can well serve to illustrate the meaning of a dehumanized study of science. In making his comparison, he predicts:

> In the first place I could get up an osteological primer so arid, so pedantic in its terminology, so altogether distasteful to the youthful mind, as to beat the recent famous production of the head-masters out of the field in all these excellences. Next, I could exercise my boys upon easy fossils, and bring out all their powers of memory and all their ingenuity in the application of my osteo-grammatical rules to the interpretation, or construing, of those fragments. To those who had reached the higher classes, I might supply odd bones to be built up into animals, giving great honor and reward to him who succeeded in fabricating monsters most entirely in accordance with the rules. That would answer to verse-making and essay writing in the dead languages.
>
> To be sure, if a great comparative anatomist were to look at these fabrications he might shake his head, or laugh. But what then? Would such a catastrophe destroy the parallel? What, think you, would Cicero, or Horace, say to the production of the best sixth form going? And would not Terence stop his ears and run out if he could be present at an English performance of his own plays? Would Hamlet, in the mouths of a set of French actors, who should insist on pronouncing English after the fashion of their own tongue, be more hideously ridiculous?[1]

[1] Huxley, Thomas Henry, *Collected Essays*, Vol. III, p. 99, New York, D. Appleton and Company, 1897.

An examination of certain modern programs of science would lead one to believe that some science teachers have been so intrigued by Huxley's parallel that they are doing in their science teaching the very thing which he satirized. Such a situation can be partly attributed to the ease with which science can be dehumanized in the hands of inhumane teachers. Science encourages repetition of operations with no sense of their significance; it converts nature into symbols and concepts which then tend to become divorced from human experience; it produces machines which may be used to mechanize human life. An undue emphasis upon these aspects of science can only result in the loss of that humanity which is an essential of any true science. This dehumanized science, like any other dead machine, can do some routine things. But as we have been reminded often, "Actual science is not dead and the great scientific discoveries have not come by close adherence to the standardized formulas of mathematical precision or logical rigor. The flash of insight which starts a genius on a long series of observations and experiments resulting perhaps in the validation of a new scientific principle doubtless has causes. And these causes are to be sought within the person of the man, not in any adventitious external happenings. No external event can give us insight. An original idea will not be generated if the makings are not already there in the conscious and unconscious organization of its inventor."[2]

It would seem then that if science teachers are to recover and teach the real nature of science, they must humanize their teaching of science. They must heed Dewey's admonition that "Knowledge is humanistic in quality not because it is *about* human products in the past, but because of what it *does* in liberating human intelligence and human sympathy."[3] They must treat science in such a way that it reveals nature as the environment of human life; they must teach it so as to illustrate the movement of man's reason and not as a monument to human reason; they must integrate it with human experience, both that of the pupil and of the scientist; they must develop an understanding of and an appreciation for the methods of science and their accompanying attitudes as a way of solving certain of man's problems. If science teaching is to be humanized, teachers must never divorce expertness from significance; they must con-

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[2] Herrick, C. J., "Little Academies I have Known," *The Scientific Monthly*, Vol. LIII, p. 134, Aug. 1941.

[3] Dewey, John, *Democracy and Education*, p. 269, New York, The Macmillan Company, 1924.

tinually relate techniques to the achievement of purposes.

Needless to say science teaching cannot be humanized by any one formula. To teach science as an on-going human activity, to avoid the rut of a dehumanized science, places an overwhelmingly difficult task upon science teachers. They must continually strive to expand their understanding not only of the findings and techniques of science but also of the history and philosophy of science. Moreover, the classroom teaching must demonstrate from day to day this expansion of the teachers' understanding.

A host of audio-visual aids are available to assist teachers in their pursuit of the two foregoing goals. Many excellent books have drawn heavily from the biographies of the great scientists. Scientific periodicals include many historical articles. Reproductions of photographs and paintings dealing with the lives and achievements of the great scientists are suggestive. Recently electrical transcriptions of radio programs portraying some phase of the life of a scientist offer some real possibilities. Educational films depicting the history of science are improving as well as increasing. It would be impossible in a single article to deal with all of the available aids. Consequently, we shall limit the remainder of this paper to a discussion of ways in which the bulletin board may be used in humanizing the teaching of science.

The use of bulletin boards for presenting materials related to science courses is not new. Few science rooms lack some kind of bulletin board for the posting of assignment schedules, direction sheets, seating plans, and other announcements of a similar kind. Too often, however, the use of the bulletin board is limited to the posting of such routine notices. In some instances we find bulletin boards which are used for exhibiting clippings and pictures related in some way to the work of the course. Very often such bulletin boards are not changed regularly and they become another fixture which students ignore. Day after day they continue their unnoticed task of "lending atmosphere to the room." The miscellaneous accretion continues to grow until finally some item must be removed to make room for one which has not been displayed. Seldom do we find a bulletin board having a suitable theme to tie all of its materials together. The possibilities of using the bulletin board to humanize the teaching of science remain practically unexplored.

One of these possibilities concerns a possible correlation of a chronological treatment of the discoveries and inventions of sci-

ence with the usual topical organization. Such a scheme requires some familiarity with the history of science. As an example, if we wish to correlate our study of certain generalizations in science with the birthday anniversaries of the scientists who made the discoveries upon which the principles are based, we shall need a calendar of the birthdays of scientists. Such a calendar for the month of *October* follows:

A CALENDAR OF THE BIRTHDAYS OF SCIENTISTS FOR OCTOBER

Day	*Year*	*Name*	*Birthplace*	*Speciality*
1	1872	Wallace Walter Atwood	Chicago, Illinois	Geographer
1	1845	William Henry Mahoney Christie	Woolwich, England	Astronomer
1	1841	Carl Hermann Credner	Gotha, Germany	Geologist
1	1819	Thomas Rupert Jones	London, England	Geologist
2	1852	William Ramsay	Glasgow, Scotland	Chemist
2	1832	Julius von Sachs	Breslau, Germany	Botanist
2	1832	Edward Burnett Tylor	Camberwell, London	Anthropologist
3	1858	Percy Faraday Frankland	London, England	Chemist
4	1858	Michael Idvorsky Pupin	Idvor, Hungary (Jugoslavia)	American Inventor
5	1789	William Scoresby	Whitby, Yorkshire, England	Scientist
5	1778	Jacques Joseph Champollion-Figeac	Figeac, France	Archaeologist
5	1873	Merritt Lyndon Fernald	Orano, Maine	Botanist
6	1803	Heinrich Wilhelm Dove	Leiguitz, Silesia, Germany	Meteorologist
5	1732	Nevil Maskelyne	London, England	Astronomer
6	1834	Alfred Joseph Naquet	Carpentras, France	Chemist
6	1846	George Westinghouse	Central Bridge, N. Y.	Inventor
9	1856	Charles Emerson Beecher	Dunkirk, New York	Paleontologist
9	1801	Auguste Arthur de la Rive	Geneva, Switzerland	Physicist
9	1852	Emil Fischer	Euskirchen, Germany	Chemist
9	1879	Max von Lane	Pfaffendorf, near Coblenz, Germany	Physicist
10	1731	Henry Cavendish	Nice	English Chemist
10	1797	Thomas Drummond	Edinburgh	Inventor
10	1811	Joseph Beete Jukes	Summer Hill, near Birmingham, England	Geologist
10	1861	Fridtjof Nansen	Fröen, near Christiania Norway	Scientist
10	1788	Johann Jacob Noeggerath	Bonn, Germany	Mineralogist
11	1758	Heinrich Wilhelm Olbers	Near Bremen, Germany	Astronomer
12	1858	Isaac Newton Lewis	New Salem, Pa.	Inventor
12	1860	Elmer Ambrose Sperry	Cortland, New York	Inventor
13	1807	Hans Conan von der Gobelentz	Altenburg, Germany	Ethnologist
13	1862	Mary Henrietta Kingsley	London, England	Ethnologist
13	1821	Rudolf Virchow	Schivelbein in Pomerania, Germany	Pathologist
14	1840	Friedrich Wilhelm Kohlrausch	Rintelu on the Weser, Germ.	Physicist
14	1801	Joseph Antoine Ferdinand Plateau	Brussels, Belgium	Physicist
14	1788	Edward Sabine	Dublin	Astronomer
15	1829	Asaph Hall	Goshen, Conn.	Astronomer
15	1608	Evangelista Torricelli	Faenza, Italy	Physicist
16	1708	Albrecht von Haller	Berne, Switzerland	Anatomist
18	1839	Johann August Mojsisavics von Majsvar	Vienna, Austria	Geologist
18	1799	Christian Friedrich Schönbein	Metzingen, Swabia, Germany	Chemist
18	1844	Harvey Washington Wiley	Kent, Indiana	Chemist
20	1854	Patrick Geddes	Perth, England	Biologist
20	1869	John Campbell Merriam	Hopkinton, Iowa	Paleontologist
21	1833	Alfred Bernhard Nobel	Stockholm, Sweden	Chemist

Day	*Year*	*Name*	*Birthplace*	*Speciality*
21	1660	Georg Ernest Stahl	Anspach, Germany	Chemist
23	1848	Arthur Rücker	Clopham, England	Physicist
24	1808	Bernhard von Cotta	Near Eisenach	Geologist
24	1632	Anthony van Leeuwenhoek	Delft, Holland	Microscopist
24	1830	Marianne North	Hastings, England	Naturalist
24	1854	Hendrick Willem Roozeboom	Holland	Physical Chemist
24	1804	Wilhelm Eduard Weber	Wittenberg, Germany	Physicist
25	1792	Franklin Bache	Philadelphia, Pa.	Chemist
26	1877	Max Mason	Madison, Wisconsin	Inventor
27	1863	William Suddards Franklin	Geary City, Kansas	Physicist
28	1867	Hans Driesch	Kreuznach, Germany	Biologist
29	1827	Marcellin Pierre Eugéne Berthelot	Paris, France	Chemist
28	1758	John Sibthorp	Oxford, England	Botanist
29	1656	Edmund Halley	London, England	Astronomer
29	1831	Othniel Charles Marsh	Lockport, New York	Palaeontologist
30	1817	Hermann Franz Moritz Kopp	Hanau, Germany	Chemist
30	1852	Jacobus Henricus Van't Hoff	Rotterdam, Holland	Physical Chemist
31	1835	Johann Friederick Wilhelm Adolf von Baeyer	Berlin, Germany	Chemist

The above calendar is not intended to be exhaustive. It was made by arranging in chronological order the names of most of the scientists listed in the fourteenth edition of *The Encyclopaedia Britannica*. It could be extended in various ways. Any scientist whose birthday is not given in the *Britannica* will not be found in the list. Such an omission is Niels Bohr. Many living scientists are not found in the *Britannica* and are therefore missing from the calendar. The resourceful teacher will make such additions and omissions as the local situation warrants.

There are numerous ways in which such a calendar could be used. One arrangement would be to place an artistic reproduction of the calendar or a part of the calendar in the center of the bulletin board and to run ribbons from the names of the men studied in a particular unit to pictures depicting some events associated with the scientists. Thus, if a physics class is studying air pressure in October, a ribbon could be stretched from the name of George Westinghouse to a picture of the air brake, or of the man, or of the birthplace of the man. Another ribbon, perhaps of a different color, could be extended from the name of Evangelista Torricelli to a picture of a mercurial barometer, or of the man, or of the birthplace of the man. If a chemistry class is studying the atmosphere during the month of October, a ribbon could be run from the name of Georg Ernest Stahl to a representation of the phlogiston theory, or to a picture of the man, or both. Another ribbon could be stretched between the name of Henry Cavendish and a drawing of his apparatus for preparing nitrogen. A third ribbon could be extended from the

name of William Ramsay to the symbols for argon, helium, neon, krypton, and zenon.

A second method of using the calendar would be to place it in the center of the bulletin board and to surround it with cards on which questions related to the key scientists of the unit have been printed. In this way we can relate the "Ask Me Another" type of activity to the bulletin board display.

A third method in which the calendar can be used is to assist in the selection of men whose work is to be emphasized in a particular display. Thus, the teacher of biology may wish to show something of the history of the microscope during October. He could select from the list the name of Anthony von Leeuwenhoek around which to center the bulletin board display during the week of October twenty-fourth. In building the exhibit he could group pictures pertaining to the life of Leeuwenhoek around a portrait of this great microscopist.

A fourth method of using the calendar is to place an artistic reproduction of it in the center of the bulletin board and to surround it with the pictures of the scientists whose work will be discussed during the month.

These four ways of using the calendar should be sufficient to suggest numerous other arrangements to an ingenious teacher. These suggestions are not intended to imply that the chronological and topical organizations will always parallel one another. Other considerations will often determine the nature of the display. Thus, the teacher may wish to prepare an exhibit representative of the nobelists whose birthdays occur in a given month even though the current unit will not concern itself with any of the scientists included in the display. However, when such correlations as those suggested exist, the teacher should be aware of them and utilize any possibilities for humanizing the teaching of the unit to the greatest possible extent.

Two difficulties present themselves to teachers who attempt to utilize the bulletin board as an aid in the humanizing of science teaching. The first problem is that of securing reading material which is conveniently available and written so as to give some insight into the methods of investigation and the human qualities of the scientists. Although much material has been collected, it is seldom accessible to the high school teacher and not always written so as to satisfy the purposes of the high school science class. However, several collections of biographical sketches have appeared recently which should prove useful

in helping both pupils and teachers to understand the human qualities of a scientist. A group of these books are listed in the bibliography which closes this article. A few of these books should be added each year to the classroom book shelf. Many of the book length biographies of the scientists are valuable also. A few of these have been included in the bibliography. If the high school has a file of such magazines as are indexed in the various periodical indexes, additional material will be available. However, a program can be initiated with an encyclopaedia and a few of the books listed in the bibliography.

One method of accumulating a file of articles is that of collecting student reports on the great scientists over a period of years. The English and science teachers could well cooperate in such a venture. A little foresight and careful planning on the part of these teachers should result in a file of historical sketches which can be used by future classes. Those students who are not adept at writing could be assigned the task of typing or legibly writing a prepared sketch.

This same method of pupil-teacher cooperation in the bulletin board project described will do much to solve the second problem; that of preparing the material for the bulletin board. Pupils should be instructed early in the school year as to the needs of such a humanized science program. They should be on the alert for available material and for sources of such material. If the material can be clipped, it should be carefully prepared and systematically filed for future use. If it cannot be taken from its source, perhaps an art student can make a free-hand copy of the desired material.

This same cooperative enterprise can be extended to the planning and execution of a particular bulletin board display. Those students who are enrolled in both a fine arts course and a science course during a given year can help in the design of a given display, in the preparation of the necessary materials, and in the execution of the exhibit. Thus, can the language arts and the fine arts be correlated with the sciences in helping pupils to understand and to appreciate "the best that has been known and thought in the world."

A SHORT LIST OF BOOKS TO AID IN HUMANIZING THE TEACHING OF SCIENCE

1. Dampier-Whetham, William Cecil, *A History of Science*, Cambridge, University Press, 1929. xxi+514 pp.
2. Sedgwick, W. T., Tyler, H. W., and Bigelow, R. P., *A Short History*

of Science, New York, The Macmillan Company, 1939. xxi+512 pp.
Pp. 472–486: "Some important names, dates, and events in the history of science and civilization."
Pp. 487–500: "A short list of reference books."

3. Usher, Abbot Payson, *A History of Mechanical Inventions*, New York, McGraw-Hill Book Co., 1929. xi+401 pp.
4. Burlingame, Roger, *March of the Iron Men*, New York, Charles Scribner's Sons, 1938. xvi+500 pp.
"A social history of union through invention."
5. Locy, William A., *The Story of Biology*, Garden City, N. Y., Garden City Publishing Co., Inc., 1925. xvi+495.
"This volume is an attempt to picture under one view the steps in the growth of our knowledge of organic nature from the Greek foundation to Cuvier in zoology, Hofmeister in botany, and Claude Bernard in physiology." Contains 140 illustrations.
6. Moore, Forris Jewett, *A History of Chemistry*, New York, McGraw-Hill Book Company, 1939. xxi+447 pp.
7. Cajori, Florian, *A History of Physics*, New York, The Macmillan Company, 1929. xiii+424 pp.
8. Crew, Henry, *The Rise of Modern Physics*, Baltimore, The Williams and Wilkins Company, 1935. xix+434.
9. Sanford, Vera, *A Short History of Mathematics*, Boston, Houghton Mifflin Company, 1930. xii+402 pp.
10. Bell, Eric Temple, *Men of Mathematics*, New York, Simon and Schuster, 1937. xxi+592 pp.
Contains sections on Archimedes, Descartes, Fermat, Pascal, Newton, Leibnitz, Bernoulli, Euler, Lagrange, La Place, Monge, Poncelet, Gauss, Cauchy, Abel, Jacobi, Hamilton, Galois, Sylvester, Remann, Poincaré, and others. 29 portraits.
11. Bridges, T. C. and Tiltman, H. W., *Master Minds of Modern Science*, New York, The Dial Press, 1931. 278 pp.
Contains chapters on John L. Baird, Sir William Bragg, Luther Burbank, Albert Einstein, J. B. S. Haldane, Sir Oliver Lodge, R. A. Millikan, G. C. Simpson, Sir Charles Parsons, and others. Thirty-two illustrations.
12. Crowther, J. G., *Men of Science*, New York, W. W. Norton and Company, 1936. xiii+332 pp.
Contains chapters on Humphry Davy, Michael Faraday, James Prescott Joule, William Thomson, and James Clerk Maxwell with thirteen portrait plates.
13. Crowther, J. G., *Famous American Men of Science*, New York, W. W. Norton and Company, 1937. xvi+414 pp.
Contains chapters on Franklin, Henry, Gibbs, and Edison.
14. Darrow, Floyd L., *Masters of Science and Invention*, New York, Harcourt, Brace and Company, 1923.
Contains chapters on Galileo, Henry, Darwin, Pasteur, Agassiz, Bunsen, Helmholtz, Nobel, Perkin, Westinghouse, Edison, Bell, Marconi, and others.
15. Hart, Ivor B., *Makers of Science*, London, Oxford University Press, 1923. 320 pp.
Contains chapters on Aristotle, Roger Bacon, Copernicus, Kepler, Gilbert, Galileo, Descartes, Newton, Boyle, Ampere, Davy, Ohm, Faraday, and Kelvin with 124 illustrations.
16. Hylander, C. J., *American Inventors*, New York, The Macmillan Co., 1934. xv+216 pp.
Contains chapters on Franklin, Fitch, Evans, Whitney, Stevens,

Fulton, McCormick, Howe, Morse, Ericsson, Goodyear, Sholes, Westinghouse, Bell, Holland, Berliner, Edison, Jenkins, DeForest, and others. 54 illustrations.

17. Jaffe, Bernard, *Crucibles*, New York, Newton Publishing Co., 1930. viii+378 pp.
    Contains chapters on Trevison, Paracelsus, Becher, Priestley, Cavendish, Lavoisier, Dalton, Berzelius, Avogadro, Woehler, Mendeleeff, Arrhenius, Marie Curie, J. J. Thomson, Moseley, and Langmuir with 24 illustrations.
18. Kendall, James, *Young Chemists and Great Discoveries*, London, G. Bell and Sons Ltd., 1939. xvi+272 pp.
    Humphey Davy, Michael Faraday, some young organic chemists, and some young American chemists are included.
19. Trattner, Ernest R., *Architects of Ideas*, New York, Carrick and Evans, Inc., 1938. 426 pp.
    Contains chapters on and portraits of Copernicus, Hutton, Dalton, Lavoisier, Rumford, Huygens, Malthus, Schwann, Darwin, Marx, Pasteur, Freud, Chamberlin, Boas, and Einstein.
20. Weeks, Mary Elvira, *The Discovery of the Elements*, Easton, Pa., Mack Printing Co., 1935. iii+371.
21. Wilson, Grove, *The Human Side of Science*, New York, Cosmopolitan Book Corporation, 1929. xi+397 pp.
    Contains chapters on Democritus, Aristotle, Archimedes, Ptolemy, Galen, Roger Bacon, Copernicus, Paracelsus, Brahe, Harvey, Kepler, Galileo, Newton, Lavoisier, Lamarck, Faraday, Pasteur, Darwin, Mendel, Hertz, Langley, Einstein and others. Twelve portraits.
22. Curie, Eve, *Madame Curie*, (Vincent Sheean, Tr.), New York, The Literary Guild of America, Inc., 1937. xi+393 pp.
23. Compton, Piers, *The Genius of Louis Pasteur*, New York, The Macmillan Company, 1932. ix+361.
24. Fahie, J. J., *Galileo, His Life and Work*, London, John Murray, 1903. xvi+451.
25. McKie, Douglas, *Antoine Lavoisier*, Philadelphia, J. B. Lippincott Co., 1935. 303 pp.
26. More, Louis Trenchard, *Isaac Newton*, New York, Charles Scribner's Sons, 1934. xii+675.
27. West, Geoffrey, *Charles Darwin, A Portrait*, New Haven, Yale University Press, 1938. xv+359 pp.

BLUE PRINTS IN THE JUNIOR HIGH

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I wish to cite an example of what seems to me to be a good illustration of the correlation between chemistry and physics. A blue print showing the magnetic field between two like poles was prepared by a junior in our high school. A piece of cheap typing paper was coated with a solution of ferric ammonium citrate and potassium ferricyanide in water. This paper was dried in the dark, then laid over like magnetic poles and sprinkled with filings. After being exposed to the sun until the paper became a deep blue, the print was washed for five minutes and then dried.

This boy is an assistant in a junior high school science class, and prepared the demonstration on his own initiative.

THE MATHEMATICS OF WAR BULLETINS

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By their very nature wars are mathematical. The purpose of war is the achievement of victory, and victory means the demonstration of an inequality, the inequality in the strength of the two opponents. War could, therefore, be defined as a collective enterprise whereby a social unit establishes the sense of an inequality between its own power and that of another unit. Total war is undoubtedly the most logical kind of war. For it aims to bring the totalities of power possessed by the two conflicting parties into relation so that any existing inequality may become demonstrable. The premises of an enduring peace, too, are endowed with a mathematical quality. For hundreds of years the peace of Europe was conditioned on the existence of an equation of power, called the "balance of power." One is tempted to oversimplify the matter by saying that the wars of the Old World have resulted from inequalities of power between competing political groups whereas a state of peace coexisted with an equality of power.

However, we are not concerned here with hazy historical speculations; merely with the fact that mathematical concepts lie close to the root of power politics, that a nation's foreign policy, to be successful, must have some of the rigor of mathematical thought in it, and that, in consequence, a people will stand a better chance of survival in a world of competitive power if it permits its thinking to be disciplined by that supreme taskmaster of clear and ordered thinking, mathematics.

It hardly need be pointed out that the strategy of war is a form of applied mathematics. There are both an arithmetic and a geometric constituent in military strategy, one the numerical strength of the forces employed, the other the space in which they move. As motion also involves the element of time, the complete triad reads: numerical strength, space, and time; all three the very stuff of mathematics. Through the employment of unique and novel patterns in the combinations of these three materials the great military men of the ages have won their eminent victories. From the phalanx formations of the ancient Greeks and the numerical divisions of the Roman armies, through the new tactical situations created by the introduction of fire-arms and explosives, to the "Blitzkrieg" of our own days,

based on airplanes and tanks, military history is but the story of an ever-changing, evolving pattern in the relationship of number, space, and time. Such time-honored military terms, as "envelopment," "encirclement," "flanking attack," "inner lines," "outnumber," suggest the inevitable premises, both geometric and arithmetic, of warfare.

Should a teacher use the mathematics of warfare as a life-situation? If there were a reasonable assurance that wars could be permanently abolished, he certainly should not. But it is most unlikely, especially after the blatant failure of the League of Nations, that such an assurance will be forthcoming within the life-time of this generation. The conclusion appears, therefore, inescapable that a widely diffused understanding of the rudiments of war strategy ought to be an integral part in the defense of American democracy, and the extent to which such rudiments can and should be imparted in the public schools ought to be a subject for professional deliberation at this very moment. As a contribution to such a discussion I wish to suggest that military science, as every other science, has a producer's and a consumer's aspect. Within the scope of general education the producer's phase of military mathematics cannot receive more than the most casual mention; for instance, problems about military aviation might be included among verbal equations, and practices of gunnery can yield illustrative examples in trigonometry. But scarcely more than that can be done. For, after all, the public schools are not charged with the task of training soldiers. The consumer's phase of military mathematics, however, might very well be considered part and parcel of a general education, a preparation for good citizenship. As problems of foreign policy, in greater number and ever greater complexity, are calling for choices and decisions on the part of the citizenry, concomitant questions of military policy inevitably arise. Foreign policy, except in Utopia, has always been inseparable from military policy. The soundness of the choices and decisions made will greatly depend on the correct appraisal of the mathematical factors inherent in all military situations. Here lies, therefore, an opportunity for the mathematics teacher, and he can very well assume his share in the "education of the consumer" of military science.

The subject has many and important ramifications; in this article our focus will be on one of them exclusively. The average citizen forms his ideas regarding military science principally on the basis of current news obtained from newspapers and maga-

zines. As he reads about the present war, he intuitively formulates his own conclusions regarding military policy. News of the war is unusually rich in mathematical contents. The reader who wants to judge intelligently for himself must be able to analyze and interpret these mathematical contents correctly. If the semantic movement has swept into being the subject of "propaganda analysis," if teachers of language concern themselves legitimately with the meaning of words, the interpretation of language, spoken and written, then the same impulse must make itself felt in the field of mathematics and urge the teachers of mathematics to help their pupils analyze the mathematical content of current news.

How much there is to analyze, interpret and evaluate! Hardly a day passes that does not bring its crop of numerical claims and assertions put forth in official bulletins and unofficial dispatches. In the following we shall apply a very elementary kind of mathematical reasoning in order to analyze certain military situations which have figured in the news of the present war. There is, first of all, the accounting of casualties suffered or inflicted, the most common numerical ingredient of war bulletins. Because such quantitative statements must always be interpreted proportionally, they lend themselves well to the demonstration of the two methods for comparing numbers, namely, comparison by difference and comparison by ratio.[1] It is the ratio of losses to the total strength in action that counts rather than the actual number. It may, for instance, happen that in a certain action the losses of the two adversaries are precisely equal, yet the advantage will almost invariably lie with the numerically stronger contestant. The conclusion can be neatly proved by assuming some proper fraction, representing the ratio between the unequal forces of the adversaries and subtracting the same positive number from numerator and denominator. The subtracted number represents the equal losses sustained by the two parties. The value of the fraction has decreased; the ratio has been shifted to the disadvantage of the numerically inferior party. Such was evidently the case in the recent war between Russia and Finland. The converse is true if an equal increment is added to the strength of two unequal opponents. For example, two powers enter the war with unequal air forces and are able to add equal net increases during the course of the war. The advantage goes here to the numerically inferior party because the fraction repre-

[1] *Mathematics in General Education*, D. Appleton-Century Co., p. 177 ff.

senting the ratio between the two air forces increases as equal numbers are added to numerator and denominator.

The listing of losses of any kind is always subject to the fundamental error of incorrect grouping. A concrete number is intended to give the size of a group, but unless the group is properly chosen and defined, the number may be meaningless. The total French losses in wounded and killed during the campaign of 1940 were, on the whole, astonishingly low. A recent French report,[2] however, revealed that the ratio of casualties (exclusive of prisoners) for officers and privates was about 1:3, i.e., proportionally speaking, a much larger number of officers was put out of action than private soldiers; hence the military effect must have been considerably greater than the mere number of casualties would have indicated. The importance of the special technical branches to the success of the war machine further emphasizes this point. The loss of 1,000 fully trained airplane pilots may be much more severe than that of 100,000 indifferently trained foot soldiers. Since no bulletins give detailed accounts of such losses, it is well-nigh impossible for the layman to appraise the ultimate effects of a temporary victory. Only a properly grouped analysis of all losses involved can have any revelatory value.

The same kind of difficulty beclouds the current reports about shipping losses. The author remembers two analyses by well-known experts writing in leading metropolitan papers about the same time and arriving at diametrically opposite conclusions as to the effectiveness of the German campaign against British shipping. The total tonnage lost as reported in official bulletins bears, of course, a relation to the outcome of the war, but the relation is complicated by the intrusion of many factors unknown and unknowable to the layman. The effect on the final outcome could very well be represented as a function of many variables, of which only one is given, the actual tonnage destroyed. Most of the other variables cannot even be guessed, such as the economic and military value of the cargoes lost, the exact figures of replacement due to capture of enemy vessels and new construction, the slowing up of deliveries through the convoy system, and the like. There is a special aspect of the war at sea, however, which lends itself to a neat mathematical analysis by the layman; that is the difference between an enemy ship captured and an enemy ship scuttled before capture was ef-

[2] Summarized in the *New York Times*.

fected. The tonnages of opposing navies are best represented by signed numbers, one's own ships being recorded as positive and enemy vessels as negative. If such negative tonnage is lost by capture, the mathematical operation symbolizing the event would be the subtraction of negative tonnage, which is equivalent to the addition of positive tonnage to one's own merchant marine. On the contrary, if the enemy ship was scuttled to escape seizure, the military effect depends upon whether or not the enemy ships are being used for the transportation of goods across the seas. The war effectiveness of a completely blockaded merchant marine is equal to zero; if any part of this fleet is destroyed, the military effect is again zero because any number multiplied by zero makes zero. The size of the blockaded merchant fleet does not count in a military way. In this war the destruction of a British and a German ship does not cancel because the former is part of a fully operating merchant fleet whereas the latter is not. The same sort of reasoning applies to harbor works whose destruction becomes more significant in the same proportion as the harbor is used for the shipping of vital supplies.

With regard to shipping losses the consumer of war bulletins must resign himself to an enforced state of ignorance, but he is in a good position to judge for himself the validity of a report which appeared during the summer of 1940 when an invasion of the British Isles by German land forces was seen as a strong possibility. At that time dispatches told of a "ring of steel" which Germany was preparing to throw around the channel area by means of long-range guns in order to provide a screen behind which a large-scale invasion of the Isles could be safely carried out. Diagrams accompanying these reports showed the range of alleged German channel guns as being about forty miles and the reader was to gain the impression that, covered by a barrage from these tremendous guns, an invader would have a relatively simple task ahead. It takes only a few multiplications and divisions to prove the fallacy of the conclusion. Let us assume that the "ring of steel" would be a semi-circle with the center at a certain point on the French coast, say at Calais. The length of this semi-circle would be about 125 miles. How many guns and how many shells per gun would it take to lay an effective barrage along a front of this length? Since part of the line is over water, which might be guarded in some other way, let us make the conservative assumption that only a front 50 miles long were

to be sealed by a devastating artillery bombardment. To plant shells along a front of this length in regular intervals of 100 yards the invader would need at least 880 shells. Now, it is well-known that these long-range super-guns, aside from the difficulties of aiming, wear out very quickly, thirty rounds of ammunition being given for the capacity of the gun with which the Germans bombarded Paris during the First World War.[3] How many guns would then be required to make only a single row of shell craters along the given front, and what would be the military importance of it? The situation is too fantastic and ridiculous to deserve any further discussion; but are we not compelled to inquire, when we see such stories presented in all earnestness: What is the mathematical intelligence of the reading public? Because of their reflection on the mathematical abilities of the products of our public schools such stories do become the concern of the mathematics teacher.

The random bombardment of a city from the air furnishes a strange and tragic application of a geometric progression. When the bombardment of London began in the fall of 1940, Mr. Churchill stated in the House of Commons that if the raids concontinued at the same rate it would take ten years to destroy all of London, allowance being made for the same houses being hit over and over again.[4] The last-mentioned proviso suggests that in random bombing, such as night-raiding involves, the rate of destruction follows a geometric rather than an arithmetic progression, and this is the only fact from which the suffering party may derive some consolation. Let us assume that all the successive bombardments against a city area were equal in severity, and that all the buildings destroyed were rated equally as to their importance and value. Then the number of buildings left intact after each attack form the members of a geometric progression whose ratio is less than unity. Theoretically it would take an infinite number of bombardments to erase the buildings of the area, but, of course, the vanishing point is reached much sooner for all practical purposes. If the effectiveness of a single random bombardment is known, however, it should be possible on the basis of probability to calculate by what time the majority of the vital objectives will be destroyed.

The war in the air has brought to the fore the characteristics of warfare in three-dimensional space, and it is not difficult to

[3] See *Encyclopedia Britannica*, 14th Edition, Vol. II, p. 470.
[4] Reprinted in the *New York Times*.

arrive at certain generalizations as to the effect of the three dimensions upon warfare in general. For the sake of speculation, let us inquire what war would be like if fought by one-dimensional beings, that is by beings that can only move in straight lines along a given direction (exactly opposite directions being assumed for opposing forces). Victory in such a combat would be determined solely by the inequality of force; the stronger party would inevitably win. If, for example, two one-dimensional warriors clashed, the one possessed of the greater propelling force would necessarily carry the day. Into such a combat the matter of strategy, design or pattern would not enter at all, superiority of strength alone deciding the outcome. Since this one-dimensional warfare was closely approximated in primitive tribal warfare, it resulted usually in the survival of the physically most forceful group. The introduction of new weapons opened up additional dimensions of warfare. War on a level plain, permitting free movement in two dimensions, put a premium on patterns of attack and defense and often enabled a group inferior both in individual strength and numbers to triumph over a superior foe. If mountainous terrain added another dimension of movement, the chances of survival became still better for the members of the otherwise weaker group. In the war at sea the submarine introduced the additional dimension, albeit to a limited extent, and again we see the advantages reaped by the navy inferior in number of ships and tonnage. The same advantage applies to the airplane, only in a much higher degree because its mobility in the third dimension is much greater. It is in aerial warfare, consequently, that the numerically inferior party has an excellent chance of survival, a fact clearly demonstrated by the successful defense of the British Isles in the summer of 1940. Such inequality of numbers as existed between the opposing air forces at that time would have resulted in almost certain defeat for the weaker party had the contest taken place between land forces moving only in two dimensions. The additional dimension proved the saving grace of the numerically inferior defense. This principle, however, becomes inoperative when the airplane strikes against a fixed target unprotected by airplanes, as is the case in night bombing. There the advantage of mobility over the fixed position puts the outcome beyond any doubt. From the illustrations given these generalizations may be derived: First, defense can only be effective if the means of defense have the same dimensional scope as the weapons of offense. Second, in-

creasing dimensions of warfare improve the chances of defense for the numerically inferior group provided it is able to take advantage of special patterns of defense. Since the conception of pattern is essentially mathematical, we find once more that mathematics is one of the keys to military strategy.

EXAMPLES OF INEXACTNESS IN AN EXACT SCIENCE

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Bertrand Russell has defined mathematics as follows: "Mathematics is the subject in which we never know what we are talking about nor whether what we are saying is true." Now while this definition expresses some of the extreme generality of modern mathematics, it should not be the criterion for secondary mathematics. It is here, as in no other place, perhaps, that a student can become proficient in learning to say just what he means and why what he says is true. Yet there are several topics in secondary algebra which are not made clear cut or exact in many books. Following are several which I have found particularly confusing.

1. Imaginary and Complex Numbers. I will not attempt to give the various definitions of these numbers which are doubtless familiar to all but will confine myself to stating definitions which will permit of no overlapping. An *imaginary number* is the (positive or negative) square root of a negative real number. This excludes 0 as an imaginary number. A *complex number* is the sum of a real number, not 0, and an imaginary number. At first glance, these definitions do not seem to cover such numbers as fourth, sixth, eighth, etc., roots of negative real numbers but DeMoivre's theorem shows that such numbers are expressible in the form defined above as complex number. There is no need for the term "pure imaginary."

2. Solution of equations of the form $x^{m/n} = k$ where m and k, and n are integers. If an equation of this form has any root it has m such roots. If n is even and k is negative, there is no solution. In other cases, the m answers can be found by raising both sides to the nth power (or $-$nth power if n is negative), then solving the resulting equation by factoring, or better by finding the mth root of the absolute value of both sides and then multi-

plying the mth root of the right hand member by all the mth roots of 1 (or -1, if the right hand member is negative). An equation such as $x^{5/3}=32$ sometimes appears on examinations which give short type questions. This is considered an appropriate short type question by some examiners apparently. But this equation has five answers which are not readily found by the average secondary student taking these examinations.

3. The partial identities, $\sqrt{a}\cdot\sqrt{b}=\sqrt{ab}$ and $\dfrac{\sqrt{a}}{\sqrt{b}}=\sqrt{\dfrac{a}{b}}$. That these are not universally true is apparent in such examples as $\sqrt{-2}\cdot\sqrt{-3}=-\sqrt{6}$ and $\dfrac{\sqrt{6}}{\sqrt{-2}}=-\sqrt{-3}$. Most books do not point out that such is the case. If the imaginary unit "i" is used in all problems involving imaginary and complex numbers, the surd rules can be followed explicitly. In a problem such as, find the product of $\sqrt{2-\sqrt{10}}$ and $\sqrt{3-\sqrt{10}}$, it is important for the student to see that $\sqrt{2-\sqrt{10}}$ and $\sqrt{3-\sqrt{10}}$ are imaginary numbers, or he is apt to give the answer as $\sqrt{16-5\sqrt{10}}$ instead of $-\sqrt{16-5\sqrt{10}}$.

PEACHES GROWN FROM FRUIT PITS IN TWO YEARS

From pits to peaches in two years is the record achieved by scientists in the University of California College of Agriculture.

Dr. W. E. Lammerts of the University of California faculty has devised a new method of speeding up nature's normal growth processes, which he calls embryo culture. Kernels are removed from the hard pits and soaked in a nutrient solution of agar, sugar and vitamin B_1 for three weeks. They sprout rapidly with such coddling and are then removed to clean washed sand, where they are kept moist for three weeks longer. Seedlings are by then large and husky enough to be placed in soil-filled pots. By the time they are nine months old, they are ready for field planting, and by their second birthday the young trees are the proud producers of fine peaches.

"The significant facts about speeding up nature's normal routine," said Dr. Lammerts, "is that the two-year breeding cycle makes it possible to study such characteristics as skin and flesh color, free or clinging pits, and chilling requirements. Accordingly, undesirable seedlings may be removed and self- and back-cross pollinations may be made every two years—all of which, in the long run, will mean bigger and better peaches for the consumer."

Dr. Lammert's experiments have been carried on for about five years at the Armstrong Nurseries in Ontario, Calif., near Los Angeles. Over 5,000 cross-pollinated seedlings have been grown and studied in that time. The embryo cultured seeds have a much higher percentage of germination than may be expected from ordinary sprouting methods.

HYDROPONICS AND AUXINS

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The development of hydroponics or soilless plant culture opens up for the student a large field of experimental work in soil chemistry, plant physiology, and horticulture. It has been known for several centuries that it is possible to grow plants without soil. In 1860 Sachs, a German botanist, was an experimenter in the field and in 1865 Knop introduced his standard solution which differs from those in use today chiefly in the omission of the trace or micro-elements.

The minerals are divided into two groups, (1) Macro-elements, which include nitrate, phosphate, sulfate, potassium, calcium, and magnesium, and the (2) Micro-elements, boron, manganese, zinc, copper and iron. While plants have a selective action on the minerals they absorb, the presence of other elements affects the amount taken up. In early growth the nitrate and calcium are of special importance. The solution should be balanced between basic and acid constituents so that it will not become alkaline by the absorbtion of the nitrate and phosphate ions with an accumulation of an excess of potassium and calcium ions.

While there can be considerable variation in the composition of the solution according to different authors and as found necessary for the growth of different plants, it has been found that a concentration of more than 2,500 parts per million of salts is injurious. An average formula is given below. It is divided into three parts and is the amount necessary to make up ten gallons of solution. The Macro-elements may be weighed out and added to the water but the Micro-elements may be divided into two parts, one containing boron, manganese, zinc and copper and the other containing iron. Because of the small amounts necessary these are made up in permanent solutions and can be used as needed. Measurements are given in grams and in level teaspoonfuls (one-eighth of an once or 1 dram equals 5 cc.)

Solution or Mixture (A)
Calcium Nitrate, $Ca(NO_3)_2 \cdot 4H_2O$ 40.2 grams or 8 t. s.
Monobasic Potassium Phosphate, KH_2PO_4 11.8 grams or 2.5 t. s.
Clauber's Salts, Magnesium Sulfate, $MgSO_4 \cdot 7H_2O$ 21.4 gr. or 5 t. s.
Ammonium Sulfate, $(NH_4)_2SO_4$ 4.6 grams or 1 t. s.

Solution or Mixture (B)
To a pint of water add 0.89 grams or one-fourth t. s. of each of the fol-

lowing, Boric Acid, H_3BO_3, Manganese Sulfate, $MnSO_4 \cdot 7H_2O$, and Zinc Sulfate $ZnSO_4 \cdot 7H_2O$. 18 cc. of this is to be added to general solution.

Solution (C)

Mix one and one-half grams of Ferrous chloride (sulfate, citrate or tartrate) with one pint of water and keep it as a stock solution. Add 60 cc. or two fluid ounces of this solution to the general solution just before using it, and then add about 5 cc. once a week.

For proper storage of the above solution (A) secure a large ten gallon crock, an enameled or wooden bucket. If a galvanized container must be used, coat the inside with a good asphalt paint and wash it thoroughly before mixing up the solution.

Some workers believe that other minerals such as silicates, selenium, and molybdenum should be present in the solution in small amounts. It has been found that the legume, Astragalus, will not grow in the absence of selenium. A number of other elements such as iodine, bromine, barium, strontium, lithium, cobalt, nickel and fluorine are found in the ashes of plants but their function is unknown.

In general, nitrates assist in the formation of proteins and hence favor development of good foliage but they retard the ripening process and the amount present should be decreased during cloudy weather or when seed is being produced. Phosphorus stimulates root growth and hastens the ripening process. Potassium is necessary for stem growth, photosynthesis, assimilation and for translocation or distribution of foods, within the plant. It is thought to protect against disease. Calcium stimulates the formation of proteins and the growth of roots. It also strengthens cell walls. In many plants it is deposited as calcium oxalate crystals. Magnesium, which is also a constituent of chlorophyll, aids in the transportation of phosphorus and in the formation of complex lipins or fats. Sulfur is believed to promote the growth of beneficial bacteria and is a component of essential proteins. Both iron and copper are necessary in the formation of chlorophyll. Copper is an algicide. Boron and silicon are necessary for the formation of seeds. Silicon collects in epidermal cells. The exact function of the zinc and manganese is practically unknown, but in an experiment carried out in Florida one part of zinc in a hundred thousand doubled the growth of alfalfa.

Water culture consists in growing plants with their roots in a solution which contains the mineral nutrients necessary for their growth. Support used depends upon the type of plant to be grown. The simplest method is to mount the plant in a split or

keyholed cork stopper which has its center holed out to fit the stem of the plant which is surrounded with a little cotton to prevent injury. The root is arranged so that it dips into a solution kept in a bottle. The plant should be germinated between sheets of blotting paper or toweling which is kept moist. When the plant is of proper size, it is transferred to the hollowed out stopper. The outside of the container should be painted or wrapped with paper to keep out sunlight and prevent the growth of algae. Except with barley and wheat, provision must be made for aeration. This can be accomplished by bubbling air through the solution for a few minutes each day by means of a glass tube and bicycle pump, or by removing the plant and pouring the solution back and forth into another vessel several times before replacing the plant. Care must be taken not to injure the roots. The continuous drip or dynamic method may be used. The solution is placed into an elevated reservoir which is fitted with a glass siphon or a moistened wick-like cloth so that the solution will drip slowly into the vessel containing the plant and the overflow will be caught in a glass vessel at a lower level. About a liter of water should flow in twenty-four hours. Water lost by evaporation must be replaced. A number of plants may be placed at descending levels and fed by the overflow from the plants above them. The plants should be sprinkled with pure water about once a week to remove accumulated salts. The solution should be renewed about every four weeks. Plants suggested for experimentation are spring wheat, summer squash, sweet corn, barley, oats, tomatoes, dahlias, marigolds, and gladioli. If light intensity is low, begonias, carnations, gloxinias and pansies may be grown.

The solution changes both qualitatively and quantitatively as it is used. The volume of solution must be proportioned to the number of plants, the stage of growth and frequency of change of solution. Control is maintained by frequent examination of the solution and by observation of the growing plants. Chlorosis or yellowing of the new growth is due most frequently to deficency in iron or managanese or to excess of calcium. Water containing sulfides, borates, manganese, selenium, fluorides and acids should be avoided. Excess sodium chloride and water that contains lead or zinc from metal fixtures, tanks or screens and those that have been in contact with coal or pine tar are toxic. The bicarbonates, sulfates and chlorides of calcium and magnesium which make up the usual hardness of water have little

effect is present in amounts less than one hundred parts per million. If in larger amounts the metals may be precipitated by sulfuric acid, the calcium nitrate may be left out of the formula, or the solution may be changed more frequently.

In larger installations, rectangular tanks about four feet wide and six inches deep are used. These may be made of metal, cement, or of wood which is coated with asphalt paper and fastened with tie rods. Before using a cement basin, it should be leached with water for several days until it becomes neutral. Metal and cement tanks should be coated with asphalt paint. The plants are supported on wire screens stretched so that they do not sag. A one inch mesh screen should be covered with a litter bed three or four inches thick consisting of shavings, excelsior, saw dust, rice hulls or sphagnum. A mixture with the coarser material at the bottom is generally best. A layer of burlap may be used for small seedlings. The screen is arranged so that the ends of the roots will be in the liquid but a small air space will separate the liquid from the supporting material. Control this space by an overflow pipe. The plants may be aerated by raising the screen for a short time each day or better by pumping the solution in at one end of the tank and allowing it to overflow at the other. The depth of the liquid should be about four inches except with trees or long-rooted perennials. Maintain temperature of the liquid at about 70°F. Artificial illumination is costly and generally unsatisfactory because of the heat developed. The red-green part of the spectrum is active in photosynthesis while the violet rays are destructive. Seeds may be sprouted on the seed bed or rooted in sand moistened with diluted solution.

In addition to water culture, plants may be grown by sand aggregate culture and by subirrigation. All use the same basic solution as long as the total concentration does not exceed about 2,000 parts per million.

In aggregate culture, used mostly for flowers, the young plants are mounted in a bed of coarse sand (retained by a 20 to the inch mesh) granite chips or cinders. The sand should not contain more than ten per cent of calcium carbonate or it will precipitate phosphates and sulfates. A small amount acts as a buffer, preventing rapid increase in the amount of acid in the solution. Soak the sand in dilute sulfuric acid for a day and wash with water before using. It may well be sterilized by boiling for some time or by heating dry to a higher temperature. The sand may

be used over and over again for several years and resterilization is not necessary except when plants previously grown on it become diseased. In reusing, wash away all plant remains. If cinders are used, exclude coarse lumps, soak with one per cent hydrochloric acid for several days, then wash thoroughly. The solution is poured over the sand two or three times a day and allowed to drain away. Plants grown in sand are less subject to attack by stem and root rots, by rusts, and by infestations of red spiders or aphids.

In subirrigation, coarser sand particles are used and the aggregate is flooded from three to six times a day for short periods of an hour or thirty minutes. If plants are slow to root, solid nutrient mixture may be added to the litter close to the plants. This finds application in some large commercial plants.

It is of the utmost importance, in growing plants by these newer methods, that the great physiological factors of proper humidity, temperature, oxygen supply, and exposure to sunlight be maintained. The length of exposure to sunlight and the temperature may be used as a control over flowering and budding. Apparently roothairs are of less importance in water cultures than in the soil. In addition to the maintenance of the proper concentration of minerals in the solution in which the plants are growing, several other factors are of importance. Among these are (a) proper acidity or hydrogen ion concentration, (b) control of the osmotic pressure or total concentration of the solution, (c) the absence of poisonous substances, (d) protection against molds and the damping of organisms and, (e) the presence of the necessary auxins or growth hormones. Minor factors such as the age, dormancy and general adaptability of the plants and the time of year make necessary that the technique of growth for each species be studied.

Nearly all plants do best when the soil solution is slightly acid, that is with a pH of from 4.8 to 6.5. Solutions should be tested frequently with a water testing outfit such as is used in aquarium control. Various indicators may be used. Bromthymolblue changes to a yellow color at a pH of 6.00 which is about the proper concentration for most plants. With this indicator, green shows a neutral reaction while blue is alkaline. Bromcresolblue and phenol red are other common indicators. Withdraw a small amount of the liquid from the solution and add a few drops of the indicator. The resulting color will show whether or not the solution must be corrected. If too alkaline, neutralize the sample

with a three per cent solution of sulfuric acid and add an aliquot amount of the acid to the main solution. If the solution is too acid neutralize with lye or lime water (calcium hydroxide). A solution, if too acid or alkaline, affects the root growth and the amount of available iron.

Osmotic pressure is determined by the molecular and ionic concentration of chemicals in the solution. The concentration of salts present must not be so great as to reverse the osmosis of solutions and cause harm to the life processes of the plants. A three-tenths per cent solution is about the upper limit for most plants. As plants grow older they absorb smaller amounts of nutrients and as growth slows up, store more substances in their tissues. Excess osmotic pressures are controlled by washing the plant and substratum from time to time with pure water and by changing the nutrient solution. The hardness in the water must be considered if it is high in sodium chloride.

Many plants give off waste products through their roots which are inimical to the growth of other species. This is indicated by wilting, drooping, yellowing or spotting of the leaves and by malformation of roots and branches. This is of importance in the growing of multiple crops. Onions, potatoes and corn; celery, potatoes and tomatoes; Holland bulbs, gladioli, dahlias and chrysanthemums are groups that can be grown together.

Damping off fungi can be controlled, in part, by sterilization of the litter or sand before use, by providing for the proper oxidation of the roots and crowns of the plants, and by having a thin layer of dry material on the upper surface of the litter. Litter must not pack so tightly as to prevent the entrance of air.

Water culture is being used experimentally on a commercial scale. It has the following advantages; (1) Weeds are eliminated and cultivation is unnecessary. (2) Insects and other pests are easier to control. (3) The yield per unit of area is frequently increased. Light is the only factor which limits the number of plants that can be grown in a given space. Yield may be increased five times. Experimenters in California claim an increase of seven times in tomatoes and twenty-one times for potatoes. When used in multiple cropping, the yields become fantastic. Many greenhouses are experimenting with the soilless production of carnations, stocks, melons, cucumbers and roses. The luxuriance of house plants is greatly increased and the care lessened by the use of these methods. (4) Water is conserved. Loss is by transpiration, which also is very much less than in

ordinary agriculture. There is much speculation as to the possibility of using the soilless plant culture in the great desert regions of the southwest. It has been used profitably in such places as Guam and Wake Islands where the Panamerican Airways grow fresh vegetables for the crews and passengers of the transpacific clippers. (5) Better fruits and vegetables can be produced. Tomatoes grown by water culture have little juice and so are better suited for transportation and canning, while potatoes are very mealy. These mineralized vegetables are said to have a higher calcium content than those grown in the ordinary way. Hydroponics has given satisfactory results in the cultivation of flowers and vegetables in the greenhouse where the solution can be heated to 72°F. before it is circulated through tanks. Most recently an attempt has been made to grow oriental drug plants, the supply of which is limited because of the war. In England the method is used to sprout grains fed to farm animals. This increases their palatability and food value.

The growth accelerating substances of plants or auxins are, in general, complex chemical substances, minute traces of which, apparently control all activities of the plant. Despite their great number, their action seems to be specific. Some control cell division or growth, others accelerate formation of roots, buds or fruits, still others change the period of dormancy or cause the development of unfertilized (seedless) fruits (parthenogenesis), and still others act as growth inhibitors. They may be grouped for convenience, as (1) the Vitamins, familiar in dietetics, (2) Plant Hormones or Auxones, which are formed in one part of the plant and after translocation, affect another part, (3) Heteroauxins, complex organic substances which are applied to the plants, and (4) Mineral substances. It is often difficult to determine whether these substances act as foods or as stimulants. Large amounts of the auxins are poisons, causing tumors and other malformations.

The recent development of micromethods of chemical analysis has led to the discovery of a large number of auxins. The food vitamins, A (apocarotene); B 1, (Thiamine); B 2 or G (riboflavin); B 6 or E (nicotinic acid); C (ascorbic acid) are all essential to plant growth. Many of them are produced by the plants in sufficient amounts so that growth is not further accelerated by their addition. The complex radicals, thiozole and pyrimidine, are metabolites, nutrients, used by the plants in the formation of thiamine. The purine base, adenine, ($C_5H_5N_5$), which is

one of the constituents of chromatin and which is excreted from the human body as uric acid, promotes the formation of thiamine and acts as a growth stimulant of leaves. Thiamine is found in leaves on exposure to sunlight and is used to stimulate growth after it has been initiated by a hormone. It is used in very dilute solutions of about one part in ten million. Allantoin injected into bulbs and flower branches, causes the development of earlier and larger flowers. In general, the plant hormones formed in the green shoots control development of the roots, those from the leaves control the formation of flower buds, and those formed in the roots control the growth of shoots.

The common heteroauxins contain the phenol, naphthalene and indole radicals combined with the simpler organic acids, acetic, propionic and butyric. Phenyl acetic acid is used to counteract the dormancy of tubers, bulbs and corms, so that they will begin to grow earlier in the season. Indole butyric acid and indole acetic acid are root stimulants. They are widely used commercially with cuttings that are slow to root. They are given a number of trade names, among which are auxilin or hormodin in solution, auxan or rootone as powders, and kak as a salve. When seeds are soaked in the solution, the crop may be increased as much as fifty per cent. Aminoindole propionic acid decreases root growth, while its derivative, skatole, increases it. Naphthalene acetic acid prevents apples from falling from the tree before they are ripe. As many as 98% of the apples ripen, even if they are not pollinated. It is being used in an attempt to produce seedless peppers, grapes, melons, squashes and cucumbers. The crops are increased in quantity and ripen earlier by at least a week. Commercial rooting powders contain indole acetic, indole butyric and naphthalene acetic acids. A subtance found in bean pods hastens the healing of plant wounds. This may be naphthalene acetic acid, which is said to retard bud development in the Spring and in a one per cent mixture in lanolin to hasten the healing of tree wounds.

Honey contains auxins, and when the seeds of evergreens are soaked in it, they begin growth within twenty-four hours instead of requiring as is usual several years before germinating. Honey is used to hasten the sprouting of cuttings and to increase the growth of leaves.

Colchicine, which is not considered to be a hormone, is a complex, very poisonous alkaloid found in the corms of the Autumn Crocus or Meadow Saffron, Colchium autumnale, a member of

the Lily Family. It was formerly used in the treatment of gout and rheumatism. When a dilute solution of colchicine is sprayed on the leaves or when the tips of the young plants are bathed in a one-tenth per cent solution for one to six hours, while the roots are carefully protected from drying out, the number of chromosomes is doubled (duploploidy). In some plants they can be trebled (tetraploidy) or quadrupled (otoploidy). Such plants produce stalks of increased size and the flowers are more open, larger, and tend to be doubled. With some plants such as oranges and tomatoes, the solution is injurious. Colchicine crystals sell for about three dollars a gram. The solution is supposed to be very poisonous and should be handled with rubber gloves.

On the various inorganic auxins, carbon monoxide was the first root stimulant to be discovered. The gas, ethylene, C_2H_4, found in illuminating gas and widely used in the yellowing of citrus fruits and as an anesthetic, is produced in small amounts in stored apples. It initiates root growth and may cause roots to occur on the upper branches or even on leaves. Leaves of tomatoes that are exposed to ethylene grow downward due to the more rapid growth of the upper surface. Ethylene chlorhydrin and sodiumthiocyanate cause potatoes, which must ordinarily remain dormant for several months before they will grow, to sprout immediately when they are dipped into one of the solutions.

The disadvantages of hydroponics are the rather high cost of installation of the tanks and circulating machinery and the increased cost of maintenance, operation and chemical control. The chemicals used, when bought in large quantities cost from two to five cents per pound. The highly purified (C.P.) chemicals need not be used. The amounts used are about a pound per hundred gallons of solution which averages about one-tenth of a one per cent solution.

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ACTIVITIES, CONTENT, AND OBJECTIVES OF RECENTLY PUBLISHED ELEMENTARY SCIENCE UNITS

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Elementary school teachers who are interested in teaching science usually find it necessary to look for help. One of the logical sources should be the science units that have been published in current periodicals. These units are presented in various ways, but in many instances, they include objectives, subject matter, and activities that are clearly and concisely stated.

What help can an elementary school teacher get from these published units? To answer this question, 106 recently published elementary science units were critically analyzed and summarized. These units were found in the periodicals listed in Table I. The right-hand column shows the number of units found in each periodical.

TABLE I. SOURCES OF ELEMENTARY SCIENCE UNITS

Name of Magazine	*Units Reviewed*
Grade Teacher	39
Instructor	33
Science Education	9
Midland Schools	8
SCHOOL SCIENCE AND MATHEMATICS	5
American Childhood	4
School (El ed)	3
Baltimore Bulletin of Education	1
Clearing House	1
Education	1
Education Method	1
Sierra Educational News	1
Total	106

With the data accumulated, it is possible to answer a number of questions concerning elementary science. We are assuming that the questions answered are typical of those that arise in the minds of other teachers. The examples used in answering the questions are taken from one or more of the 106 units. While the comments accompanying the examples are opinions of the writ-

ers, it should be remembered that these opinions are based upon the examination of many elementary science units.

I. What are the objectives of science teaching in the elementary school?

The general objectives of elementary science teaching are well defined but many of them are equally applicable to other fields of study. The following statements are representative of the objectives listed in the published units.

1. Interest the child in his environment.
2. Utilize children's interests.
3. Sharpen the powers of observation.
4. Arouse interests that may become hobbies.
5. Provide for growth in scientific attitudes.
6. Show cause-effect relationships.
7. Encourage experimentation.
8. Encourage initiative.
9. Develop wider interests in reading.
10. Provide centers of interest to motivate work.

As stated in the published units the specific objectives are often vague and meaningless. Quite often no specific objectives are stated. Some of the more clearly stated ones are:

1. Help pupils learn the proper care of the eyes.
2. Teach the importance of good eyesight.
3. Make an aquarium like the natural habitat.
4. Help pupils learn the uses of trees to mankind.
5. Teach the values of birds to mankind.
6. Present the industrial value of rocks and minerals.
7. Help pupils learn how to care for growing flowers.
8. Present the parts of flowers and their uses.
9. Enable the child to handle simple electric wiring problems in the home.
10. Give knowledge about bacteria, their growth, and their effect upon other organisms.

II. How is elementary science correlated with other subjects?

Many teachers evidently attempt to unify their teaching by using the science unit as a core around which to build lessons in other subjects. Most of the units incorporate work-type reading lessons. Attempts are made to use arithmetic skills in problems that arise in the class period. Spelling words that are related to the unit are often studied. Specifically, one unit suggested 68 spelling words in connection with a study of the stars. Representative activities suggested in the 106 units relating the science to English, history, and geography are cited here.

Activities related to English:

1. Write a science newspaper.

2. Write original plays using the knowledges gained in unit.
3. Write business letters.
4. Write letters of invitations to science programs.
5. Prepare oral reports.
6. Check English correctness in oral contributions.

Activities related to history:

1. Find out what men knew about electricity and magnetism 2,000 years ago.
2. Trace the development of the methods of measuring time from early days to the present.
3. Study the history of artificial lighting from the early cave man to the time of our electric light.
4. Study the historical development of uses of rocks and minerals.
5. Study the history of astronomy.
6. Study the life of Alexander Graham Bell and his contribution to science.
7. Report on these historical trees: Penn's Treaty Tree (elm); Charter Oak; Boston Liberty Tree; Washington's Elm; Burgoyne's Elm; the Cary Tree.

Activities related to geographic locations:

1. Locate the chief potato producing countries of the world.
2. Find and locate on an outline map seven major trunk lines of bird migration between North America and South America.
3. Locate the forests of the United States.
4. Study the turpentine industry of the South.
5. Study the commercial value of lumber, rubber, cork, paper, rayon cloth, ship building, fruits, nuts, maple sugar, chocolate.
6. Make maps of the world showing the location of the great fertilizer beds.
7. Make maps of the United States showing areas having glacial, alluvial, lake, eolian, and volcanic soils.

III. How much use is being made of the immediate environment in teaching elementary science?

There is extensive use of local materials to teach science. Utilizing the community resources motivates pupil interest, stimulates group discussions, promotes further reading, and enhances school-community cooperation. Seeing the real materials adds authenticity and draws upon the powers of observation. In the units analyzed, fifty-three different excursions were suggested. Some typical suggestions are listed below.

1. Identify as many birds as possible.
2. Identify trees.
3. Observe bees in a bee hive.
4. Visit a local fish hatchery.
5. Visit a museum.
6. Visit a farm.
7. Visit a pond both early and late in the spring.
8. Visit a zoo.
9. Take nature walks.

Suggestions for interviewing people of special interest or listening to lectures, are illustrated by:

1. Ask a civil engineer what use he makes of compressed air.
2. Ask someone to tell you about spearing fish through the ice in winter.
3. Ask someone who has visited a mine to tell you about his visit.
4. Interview a noted astronomer.
5. Listen to an illustrated talk by a professor from a school of forestry.

Materials brought to school by the boys and girls may serve as the center of interest in the lesson. Some of the most frequently mentioned activities utilizing such materials in the classroom are:

1. Bring a hen from home and set her at school.
2. Bring rabbits, kittens, other pets, for observation.
3. Classify rocks brought to school.
4. Collect and display different kinds of soil.
5. Collect and mount different kinds of seeds.
6. Collect and mount rocks and minerals.
7. Collect old birds' nests.
8. Collect leaves, fruits, bark, and wood.
9. Investigate the nearest fire plug and fire alarm.
10. Keep a garter snake, turtle, alligator, or lizard for a short time.
11. Learn the names of your common wild flowers.

IV. What is the status of reading and reading materials in the teaching of elementary science?

Many teachers utilize the interesting reading material which science provides to teach basic reading skills. The following activities suggest the types of reading abilities emphasized in the units reviewed.

1. Fill in a skeleton outline from reading materials or class discussion.
2. Study lessons written out by the teacher. Complete the objective seatwork provided.
3. Summarize the material read by the teacher.
4. Read in supplementary readers.
5. Look at pictures to help answer questions.
6. Complete the seatwork following these directions.
7. Skim to find answers to specific questions.
8. Read maps, graphs, and charts.
9. Read biography, history, or fiction in relation to science units.
10. Look through current magazines for new applications of science in our everyday lives.
11. Build vocabulary by reading animals names, foods, sounds, etc.

There are many alternative possibilities suggesting that science can be taught without the abundance of reading materials needed for the social studies. Some of these techniques are:

1. Presentation of new subject matter by the teacher in a discussion period.
2. Organizing and clarifying the concepts the children already have.
3. Emphasizing observation—showing the child his environment.
4. Doing things instead of reading about them.

The use of activities instead of reading lessons is well illustrated from one unit on the study of electricity:

1. Examine and experiment with a dry cell.
2. Visit a power plant to get some idea of generators and dynamos which provide electricity for our homes.
3. Make an electromagnet.
4. Wire an electric bell to clarify the meaning of complete circuit.
5. Provide or construct a miniature house to wire.

V. What visual aids are used in teaching elementary science?

The use of visual aids in clarifying concepts is generally accepted as being of primary importance. Several types of visual aids were included in the units reviewed. These are typical examples.

1. Flat pictures collected by teachers.
2. Appropriate pictures from magazines brought by boys and girls.
3. Current events in newspapers for bulletin boards.
4. Lantern slides.
5. Motion picture films, both silent and sound.
6. Original drawings by classes.
7. Maps and charts.

A typical list of specific activities involving visual materials includes:

1. Collect pictures of extinct animals.
2. Collect pictures to show where food is stored in the plant.
3. Draw a flower and label its parts.
4. Make a map of the trees in the neighborhood of the school.
5. See a film on conservation of natural resources in the United States.
6. See a film on spiders, the life story and how the web is spun.
7. Illustrate by original drawings different kinds of birds' beaks, tails, and claws.

VI. What subject matter is used at different grade levels?

According to published units, science content in the elementary school has broadened from the older nature study courses. Table II shows the wide range of topics found in the investigation of the 106 units. Studying about bacteria, conservation, earth's surface, electricity, magnetism, rocks and minerals, soils, and weather has greatly increased the content making up the science program.

Table II also shows the variation of grade placement of units covering a single topic. Rocks and minerals are studied in primary, fourth and sixth grades. It is also listed as ungraded. Earth's surface, closely related to rocks and minerals, is assigned to fifth grade. Astronomy units are prepared for fourth, fifth, and sixth grades. One of the seven astronomy units was un-

graded. The great number of units about birds suggests that teachers in every grade resort to this common specimen for science teaching. In contrast, all five of the units for the study of electricity are allotted to grade six. This indicates, at least, that electricity is taught at the upper elementary level.

TABLE II. GRADE PLACEMENT OF TOPICS AS FOUND IN 106 ELEMENTARY SCIENCE UNITS

	Primary	*Fourth*	*Fifth*	*Sixth*	*Ungraded*	*Total*
Air	2	1	1	1		5
Animals, four-footed	7	5			2	14
Aquarium	1		1			2
Astronomy		2	1	3	1	7
Bacteria			1			1
Bees	2					2
Birds	6	7		1	1	15
Conservation	1		3	1	1	6
Crayfish			1			1
Earth's Surface			1			1
Electricity				5		5
Farming	1					1
Fire				1		1
Fish				1		1
Flowers	2				1	3
Foods				1		1
Forests			1			1
Health	1		1	1		3
Insects					1	1
Irrigation				1		1
Magnetism		2		2		4
Nature	1		1			2
Plants, general					1	1
Potato			1			1
Power				1		1
Rocks and Minerals	1	2		1	1	5
Seasons	2				1	3
Seeds	1	1				2
Shadows	1					1
Snails			1			1
Snow	1					1
Soils			1			1
Spiders		1				1
Time				1		1
Trees	1	2			1	4
Water				1		1
Weather	3		1			4
Winds	2	1		1		4

The following statements are brief answers to the six questions we have raised. The answers are substantiated by exemplary statements taken from one or more of 106 elementary science units that have been published.

1. The general objectives of elementary science are well defined. Some units also include well stated specific objectives.
2. Elementary science is often correlated with other subjects.
3. Teachers make extensive use of the immediate environment.
4. Teachers take advantage of elementary science reading lessons to teach basic reading skills. Many science activities do not require especially prepared reading materials.
5. Several different types of visual aids are used in elementary science teaching.
6. There is little agreement concerning grade placement of content in the units that were reviewed.

OSCILLATING CURRENT DEMONSTRATION

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The purpose in developing this demonstration assembly was to give visible evidence of the development of an oscillating current and of the projection of such a current into an aerial; and also to show by contrast certain actions of this current, and the corresponding actions of a 60 cycle alternating current.

The oscillator is of somewhat standard type, consisting of two 01A tubes in parallel, the oscillating current being developed in the coil, *A* of about 40 turns inserted between the girds and filaments. A second inducing coil, *B* of 25 turns connects the filaments and plates. These coils are wound on a 2 inch cylinder.

The 110 volt D. C. serves as a B battery, while parallel circuits from this leading through 40 watt tungsten lamps, *W*, supply current to the filaments of the tubes.

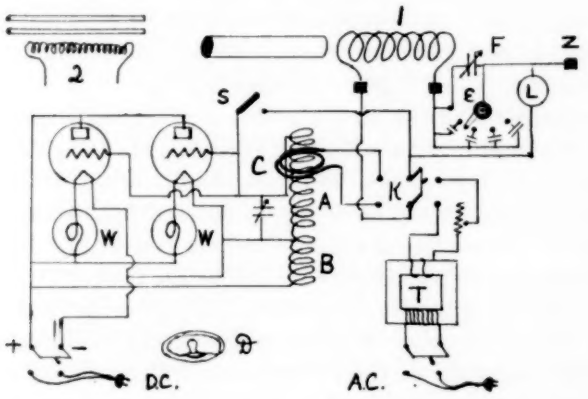
When the D. C. switch is closed and the double throw switch, *K*, is open, oscillation develops in coil *A*, tuned by the variable condenser. Proof of the existance of such oscillation may be shown by the use of coil *D*, consisting of two turns of No. 18 d.c.c. wire with the ends connected to a miniature lamp socket in which is inserted a one and one half volt flashlight bulb. This bulb glows brightly when the coil is lowered over the top of coil *A*, and the circuit is properly tuned by the condenser.

Without using coil *D*, and with *K* still open, if switch *S* is

closed and the end of an aerial running up to a picture moulding and around the room, is inserted in clamp *Z*, with correct tuning the lamp *L* will glow showing a current oscillating into the aerial.

Opening switch *S* and throwing switch *K* to the left, an oscillating current is induced in coil *C* which is now in series with coil 1, lamp *L*, and switch *E* permitting the insertion of condensers of .003, .004, and .006 M. F. capacities, or of shorting these out altogether. Variable condenser *F*, in parallel with the other condensers, enables fine adjustment of the capacities of the other three.

Coil 1 is supported by two clamps so that it may be removed and coil 2, of different size inserted. Coil 1 is of one inch radius,



APPARATUS FOR DEMONSTRATING AN OSCILLATING CIRCUIT

consisting of 8 turns of No. 18 d.c.c. wire, spread to about a three inch length. Coil 2 consists of about 60 turns of No. 18 d.c.c. wire wound closely with one-fourth inch inside diameter. (This would admit of experiments with coils of various other sizes.)

Using coil 1 and having switch *E* turned so that lamp *L* glows, it is noted that if the windings of coil 1 are compressed more closely together the lamp dims and if an iron core is inserted inside this coil there is a noticeable change in the brightness of the lamp.

Now if switch *K* is thrown to the right, this places coil 1, lamp *L*, and switch *E*, in the circuit of the secondary of transformer, *T*, through which flows a 60 cycle current. This circuit includes a resistance so that the brightness of the lamp may be

adjusted to correspond exactly with its brightness when connected in the circuit of the high frequency oscillating coil *C*.

It is now noted that there is no dimming of the lamp when the windings of coil 1 are compressed, neither is there any noticeable change in the brightness of the lamp when the iron core is inserted.

If now coil 1 is removed and coil 2 of smaller diameter is inserted and the switch thrown to the oscillating side, the lamp dims appreciably when a quarter inch iron rod is inserted in the coil, but increases in brightness when a copper rod of the same size is inserted. With the iron rod inserted the lamp changes in brightness as switch *E* is turned to change the capacity of the circuit. Also with the right adjustment of *E* and with the core partly withdrawn, the brightness of *L* may be made to decrease when the rod is further inserted or when the rotating plates of the condenser, *F*, are turned further out.

Switching now to the 60 cycle side it is noted that the lamp can not be made to glow with any adjustment of the condensers unless switch *E* is turned to short the condensers out altogether. It is also noted that the brilliancy is not noticeably changed by inserting or withdrawing either the iron rod or the brass rod. Explanation of the points noted is left to the reader.

To a class in high school physics we are pointing out that induction effects increase and capacity effects decrease greatly with large increases in the frequency of alternations, and are giving some impression of what is meant by resonance in a circuit containing inductance and capacity in series.

The transformer used here was made from a radio frequency transformer by removing the secondary and in its place winding on a considerable amount of No. 26 enameled wire, giving it a voltage somewhat less than that of an ordinary bell transformer so its current can be controlled by a regular radio tube resistor.

Accurate and minute measurement seems to the non-scientific imagination a less lofty and dignified work than looking for something new. But nearly all the grandest discoveries of science have been but the reward of accurate measurement and patient, long-continued labor in the minute sifting of numerical details.—*Lord Kelvin.*

QUALITATIVE ANALYSIS FOR HIGH SCHOOL STUDENTS

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PART I. INTRODUCTION

Study of a number of recent laboratory manuals for high school chemistry shows that the usual experiments on qualitative analysis consist of bead and flame tests for a few metals, suitable for the analysis of pure substances, tests for negative ions scattered throughout the manual, and the analysis of the silver-lead-mercurous group.

It seemed to the authors desirable to offer work in qualitative analysis as a project during the second semester of a one-year high school chemistry course. Furthermore it seemed undesirable to offer qualitative work which was not systematic and which could be used only for the analysis of pure substances. This was because most of the students will not pursue the study of chemistry further, and it seemed important that these students leave the course with a correct view of qualitative analysis as an application of scientific method to the solution of chemical problems, and that they see it as a valuable practical tool. On the other hand, the course in qualitative analysis usually given to college students was equally undesirable because there would not be time to complete it in the regular laboratory periods, some of the procedures are too difficult, and because there would not be time to study all of the reactions involved. A course in qualitative analysis is of doubtful value if the student does not gain a thorough knowledge of the reactions which take place.

With these factors in mind the authors developed a systematic qualitative scheme for the commonest metallic and non-metallic ions. It is practical for a high school course because there is time to complete it in the regular laboratory periods, the procedures are not difficult, and it is possible for the student to study the reactions which occur, and master them. Furthermore the scheme can be used for the analysis of many simple commercial products. The method has been tested thoroughly by the authors and has been used successfully for two years in their high school chemistry course.

For each group of ions students are expected to analyze a known solution which contains all the ions of the group, and to

get all the tests before they go on to the next group. This work requires 10 to 12 clock hours for the average student if he studies the procedures before coming to the laboratory, and if he follows directions for the amount of sample to use. There is a tendency for some students to use a much larger amount so that both reactions and filtrations are slowed down.

Following the analysis of the knowns the student is given simple commercial products to analyze, such as metals and alloys including candy wrappers, brass, bronze, solder, coins, pewter, galvanized iron, and tin cans. Other materials tested are water softeners, baking soda, washing soda, minerals in baking powder, face powder, non-perspirants and freckle cream. In the selection of samples care must be used so that they fall within the scope of this scheme.

Certain details, such as methods for dissolving solid samples and the making of a wash bottle are not given here as they do not differ from the methods given in any qualitative analysis text, and the student will gain a great deal from referring to such a text. In the scheme which follows when the amount of reagent is given in *ml.* a solution is indicated, while *g.* indicates a solid. Water always means distilled water. When a reagent is added to form a precipitate only a few drops are added at first. If a precipitate forms enough of the reagent is added to cause complete precipitation. Reagents, including acids and bases, are 10% solutions unless otherwise stated. Only three solutions require special directions for preparation. These are ammonium molybdate, yellow ammonium sulfide, and stannous chloride, and directions can be found in qualitative texts. When an unknown is a solid it is dissolved so that 1 gram makes about 50 ml. of solution, which is enough for the entire analysis. It is suggested that the student write balanced equations for all reactions.

Part II. Qualitative Procedures

Acid Ions (Carbonate, Nitrate, Sulfate, Chloride, Phosphate)

P.1. To 5 ml. of unknown solution add a few drops of nitric acid. Foaming with formation of an odorless gas proves the presence of a *carbonate.*

P. 2. Make 20 ml. of unknown solution basic with sodium hydroxide. Add sodium carbonate solution until precipitation is complete. Filter and use the filtrate in P. 3 and 4. Discard the residue.

P. 3. Acidify 5 ml. of filtrate from P. 2 with hydrochloric acid. Add 5 ml. of ferrous sulfate. Tilt the test tube at a 45° angle and slowly pour 2 ml. of concentrated sulfuric acid down the side of the tube. A brown ring which forms above the sulfuric acid layer proves the presence of a *nitrate.*

P. 4. Acidify the remaining solution from P. 2 with nitric acid and add 5 ml. in excess. If the volume is small bring it up to 20 ml. with water.

P. 5. To 5 ml. of solution from P. 4 add 2 ml. of barium chloride. A white precipitate, barium sulfate, proves the presence of a *sulfate.*

P. 6. To 5 ml. of solution from P. 4 add 10 ml. of ammonium molybdate. Warm the tube gently for 2–3 minutes and allow it to stand. A bright yellow precipitate, ammonium phosphomolybdate, proves the presence of a *phosphate.*

P. 7. To 5 ml. of solution from P. 4 add silver nitrate solution. A white precipitate, silver chloride, proves the presence of a *chloride.*

Procedure Preliminary to the Analysis of Metallic Ions

Removal of Phospate. If no phosphate was found in P. 6 do not do P. 8 but begin the analysis of metallic ions with P. 9.

P. 8. If phosphate was found in P. 6 add 5 ml. of nitric acid to 20 ml. of unknown solution and heat it to boiling. Test 5 ml. of this for iron by P. 22. Make the rest basic with ammonia water, just acidify it with acetic acid, add 3 g. of ammonium acetate and add ferric chloride solution until it turns brown. Heat it to boiling and filter it hot. Discard the residue of ferric phosphate. To the filtrate add 1 g. of ammonium acetate and boil gently. If a precipitate forms filter and discard the residue. Repeat until no more precipitate forms. If the volume becomes small at any time in the procedure add water to bring it to about 15 ml. Use the final filtrate in P. 10.

Metallic Ions

Ammonium

P. 9. Pour 5 ml. of ***unknown*** into a beaker, make it basic with sodium hydroxide, cover it with a watch glass on the lower side of which is a piece of moist red litmus paper. Warm it gently. If the litmus turns blue quickly it proves the presence of *ammonium* ion.

Silver

P. 10. If no phosphate was found in P. 6 use 10 ml. of unknown solution. If phosphate was found use 10 ml. of solution prepared according to P. 8. Add hydrochloric acid until the solution is acid. If it is already acid add a few drops of hydrochloric acid to see if a precipitate forms. If a precipitate forms continue to add hydrochloric acid until precipitation is complete. If no precipitate forms use this solution in P. 12. If a precipitate forms filter it, wash the residue with 5 ml. of boiling nitric acid and add the washings to the filtrate. Use the filtrate in P. 12, and the residue in P. 11.

P. 11. Pour 5 ml. of ammonia water over the residue in the filter paper. Collect the solution in a test tube and acidify it with nitric acid. A white precipitate, silver chloride, proves the presence of *silver*.

Copper-Arsenic Group (Mercury, Lead, Copper, Arsenic, Tin)

P. 12. Evaporate the solution from P. 10 nearly to dryness, add 3 ml. of concentrated hydrochloric acid and again evaporate it nearly to dryness. Add 2 ml. of concentrated hydrochloric acid and dilute to 10 ml. Heat it to boiling and saturate it with hydrogen sulfide while hot. Filter. Pass hydrogen sulfide into the filtrate and filter through the same paper. Repeat as long as a precipitate continues to form. Use the filtrate in P. 20 and the residue in P. 13.

P. 13. Stir the residue from P. 12 with 25 ml. of warm yellow ammonium sulfide. Filter. Use the residue in P. 16 and the filtrate in P. 14.

P. 14. Acidify the filtrate from P. 13 with hydrochloric acid. If a white or cream colored precipitate forms it is sulfur and indicates the absense of tin or arsenic. If a bright yellow precipitate forms filter and discard the filtrate. Remove the filter paper from the funnel and dry the residue by pressing it with with several sheets of dry filter paper. Scrape the residue into an evaporating dish and stir it with 5 ml. of concentrated hydrochloric acid. Filter through a dry filter paper. Use the filtrate in P. 15. Stir the residue with 1 g. of potassium chlorate and 5 ml. of concentrated hydrochloric acid, then filter. To 1 ml. of filtrate add 3 ml. of concentrated hydrochloric acid and 1 ml. of 20% stannous chloride. Heat to boiling. A brown or black color of free arsenic which appears within about 1 minute proves the presence of *arsenic*.

P. 15. Add a few nails or iron card teeth to the filtrate from P. 14 and boil it gently for 3 minutes. Filter into a test tube which contains 1 ml. of mercuric chloride. A white, gray, or black precipitate proves the presence of ***tin***.

P. 16. To the residue from P. 13 add 10 ml. of nitric acid and boil it 3 minutes, adding water to keep the volume constant. Filter. Use the residue in P. 17 and the filtrate in P. 18.

P. 17. Dissolve the residue from P. 16 in 2 or 3 ml. of aqua regia. Evaporate it carefully to dryness, add 1 ml. of concentrated hydrochloric acid and 5 ml. of water. Filter and to the filtrate add 1 ml. of 20% stannous chloride. A white, gray, or black precipitate proves the presence of ***mercury***.

P. 18. To the filtrate from P. 16 add 5 ml. of sulfuric acid. Boil it until dense white fumes are given off. Cool and pour it into 20 ml. of water. A white precipitate or cloudiness, due to lead sulfate, proves the presence of ***lead***. Filter and use the filtrate in P. 19.

P. 19. To the filtrate from P. 18 add 2 ml. of potassium ferrocyanide. A red-brown precipitate, cupric ferrocyanide, proves the presence of ***copper***.

Iron-Zinc Group (Iron, Aluminum, Chromium, Zinc)

P. 20. Make the filtrate from P. 12 basic with ammonia water and add 5 ml. more, add 1 g. of ammonium chloride and saturate it with hydrogen sulfide until precipitation is complete. Filter, use the filtrate in P. 26 and test the residue in P. 21.

P. 21. Dissolve the residue from P. 20 in 5 ml. of warm hydrochloric acid. Make the solution basic with sodium hydroxide. Carefully sift into the solution 1 g. of sodium peroxide while stirring it. Boil it gently for 5 minutes, dilute it with 15 ml. of water and filter. Use the filtrate in P. 23 and test the residue in P. 22.

P. 22. Dissolve the residue from P. 21 in 5 ml. of hydrochloric acid. Add a few drops of potassium sulfocyanate. A deep red color, potassium ferric sulfocyanate, proves the presence of ***iron***.

P. 23. Make the filtrate from P. 21 acid with hydrochloric acid, then make it just basic with ammonia water. A heavy white precipitate, aluminum hydroxide, proves the presence of ***aluminum***. Filter. Use the filtrate in P. 24.

P. 24. Make the filtrate from P. 23 acid with acetic acid. Divide

it into 2 parts. Use 1 part in P. 25. To the other part add 1 ml. of lead acetate. A yellow precipitate, lead chromate, proves the presence of *chromium*.

P. 25. Saturate the solution from P. 24 with hydrogen sulfide. A heavy white precipitate, zinc sulfide, which forms within 1 minute proves the presence of *zinc*.

Alkaline Earth Group (Calcium, Magnesium)

P. 26. Transfer the filtrate from P. 20 to an evaporating dish and heat it gently until about 10 ml. remain. If the solution does not already contain 1 g. of ammonium chloride (see P. 20) add it now. Test it with litmus paper and if it is not basic add ammonia water until it becomes basic. Add 5 to 10 drops of 5% ammonium oxalate. A white precipitate, calcium oxalate, proves the presence of *calcium*. Filter and use the filtrate in P. 27.

P. 27. Make the filtrate from P. 26 basic with ammonia water. Add 5 ml. of ammonium phosphate. If a precipitate does not form at once scratch the inside of the tube with a stirring rod for a few seconds. A heavy white precipitate, magnesium ammonium phosphate, proves the presence of *magnesium*. Filter. Use the filtrate in P. 29 and 30.

Alkali Group (Sodium, Potassium)

P. 28. Clean a platinum wire by dipping it in a small volume of concentrated hydrochloric acid, then heating it in the flame until it no longer gives a color to the flame. If a single treatment does not clean the wire repeat the process.

P. 29. Dip a clean platinum wire into the filtrate from P. 27 and hold it in the tip of a Bunsen burner flame. A bright yellow flame which lasts at least 5 seconds proves the presence of *sodium*.

P. 30. Dip the wire in the solution again, hold it in the flame, and view it through a cobalt blue glass. A violet flame of short duration proves the presence of *potassium*.

Part III. Explanations

P. 1. The addition of any strong acid to a carbonate causes carbonic acid to form and this breaks down rapidly to form water and carbon dioxide. It is this gas escaping that causes the foaming.

P.2. The purpose of adding sodium carbonate to the basic solution is to precipitate the carbonates of all except the alkali

metals. The presence of other metals might interfere with some of the tests for acid ions.

P. 3. Where the nitrate solution is in contact with the layer of sulfuric acid it becomes a powerful oxidizing agent and changes some ferrous ion to ferric. The nitrate is reduced at the same time to nitric oxide. An unstable dark brown compound which has the formula $FeSO_4(NO)_x$ is formed. If the concentration of nitrate is great so that all of the ferrous ion is oxidized to ferric, a red compound, $Fe_2(SO_4)_3(NO)_4$ is formed. These colors disappear on standing or if stirred or heated, because the compounds are unstable. If nitric acid is tested instead of a nitrate the entire aqueous layer may turn brown when the ferrous sulfate is added.

P. 4. Nitric acid is added because nitrate has been tested for and its presence will not interfere with the other tests.

P. 5. All white salts of bariums except the sulfate are soluble either in water or in acids.

P. 6. The equations for the formation of ammonium phosphomolybdate are: $Na_3PO_4 + 3HNO_3 \rightarrow H_3PO_4 + 3NaNO_3$

$H_3PO_4 + 12(NH_4)_2MoO_4 + 21HNO_3 \rightarrow (NH_4)_3PO_4(MoO_3)_{12} + 21NH_4NO_3 + 12H_2O$

P. 7. All white salts of silver except the chloride are soluble either in water or in acids.

P. 8. Phosphate ion must be removed before the Iron-Zinc Group is precipitated. If it is not removed, phosphates of calcium and magnesium will be precipitated with the Iron-Zinc Group and the analyst will fail to get the tests for these metals. The nitric acid changes ferrous ion to ferric so that it can be tested by P. 22 which is a test for ferric ion only. Iron is tested for at this time because ferric chloride is to be added to remove the phosphate.

It may seem strange to make the solution basic, then immediately acidify it. However, at the start of this procedure the solution is acid with nitric acid, a strong acid. For removal of phosphate the acid ion concentration must be small. Hence the solution is neutralized to remove the strong acid, and it is acidified with acetic acid which is weak. Ammonium acetate is added to still further reduce the concentration of acid ions. In this faintly acid solution ferric phosphate is precipitated while phosphates of calcium and magnesium are not. The solution must be filtered hot because ferric phosphate becomes more soluble as it cools.

P. 9. Ammonium salts react with strong bases to form ammonium hydroxide. This decomposes rapidly when heated to form ammonia gas and water. If the solution boils sodium hydroxide may be carried up with the vapor and it will slowly turn litmus blue.

P. 10. Silver chloride is very insoluble in water and acids. All other white salts of silver dissolve in water or acid. Lead chloride and mercurous chloride are also insoluble. However, hot nitric acid oxidizes mercurous ion to mercuric, and mercuric chloride is soluble. Lead chloride becomes very soluble in hot water, so hot nitric acid dissolves it. Mercury and lead are tested for in the Copper-Arsenic Group.

P. 11. Because traces of mercury and lead salts may remain on the filter paper after the treatment with nitric acid in P. 10 it is necessary to apply some test which only silver ions will give. Silver chloride and ammonia water react to form a soluble salt, $Ag(NH_3)_2Cl$. This salt is stable only in an excess of ammonia water. If this is neutralized with acid silver chloride will be precipitated again. Ammonia water will not dissolve mercurous or lead chloride.

P. 12. The solution is evaporated and hydrochloric acid added to change nitrates of the metals to chlorides. Nitric acid is driven off by the heat. If this is not done nitric acid will oxidize hydrogen sulfide to free sulfur, so that it will require a great excess of hydrogen sulfide to precipitate the Copper-Arsenic Group, and the precipitate of sulfur may be mistaken for sulfides of this group. Directions for the amount of hydrochloric acid and water to add must be followed accurately. If the solution is too acid, sulfides of this group will not precipitate, while if it is too nearly neutral some sulfides of the Iron-Zinc Group may precipitate. If a Kipp generator is available it is best to precipitate the sulfides in an Erlenmeyer flask fitted with a 1-hole stopper and glass tube so that hydrogen sulfide cannot escape.

P. 13. Yellow ammonium sulfide reacts with sulfides of arsenic and tin to form soluble salts. It does not react with sulfides of mercury, lead, and copper. Yellow ammonium sulfide is a mixture of $(NH_4)_2S_2$ and higher sulfides. Typical reactions are: $(NH_4)_2S_2+SnS\rightarrow(NH_4)_2SnS_3$ (ammonium thiostannate), $3(NH_4)_2S_2+As_2S_3\rightarrow2(NH_4)_3AsS_4$ (ammonium thioarsenate).

P. 14. Addition of dilute acid causes the thio salts of arsenic and tin to break down and sulfides are again precipitated, but note

that arsenic and tin now have a higher valence. Yellow ammonium sulfide is a good oxidizing agent.

$$(NH_4)_2SnS_3+2HCl\rightarrow 2NH_4Cl+SnS_2+H_2S$$

$$2(NH_4)_3AsS_4+6HCl\rightarrow 6NH_4Cl+As_2S_5+3H_2S.$$

Stannic sulfide reacts readily with concentrated hydrochloric acid to form stannic chloride. Arsenic sulfide reacts with hydrochloric acid only in the presence of a powerful oxidizing agent such as potassium chlorate. Assume that the reaction $As_2S_5+8H_2O\xrightarrow{HCl}2H_3AsO_4+5H_2S$ occurs to only a slight extent until the oxidizing agent is added. Then as the hydrogen sulfide is oxidized the reaction goes to completion. $KClO_3+3H_2S\rightarrow 3S+3H_2O+KCl$. Stannous chloride is a good reducing agent. In a strongly acid solution it reduces arsenic acid to brown or black free arsenic, and it is oxidized to stannic chloride.

$$2H_3AsO_4+10HCl+5SnCl_2\rightarrow 5SnCl_4+8H_2O+2As.$$

P. 15. Iron reduces stannic chloride to stannous chloride, then this reduces mercuric chloride to white mercurous chloride or to black metallic mercury.

P. 16. Sulfides of lead and copper react with nitric acid to form nitrates of the metals. Mercuric sulfide does not react.

P. 17. Aqua regia is a mixture of 3 volumes of concentrated hydrochloric acid and 1 volume of concentrated nitric acid. It is a powerful oxidizing agent and changes mercuric sulfide to mercuric chloride and free sulfur.

P. 18. Sulfuric acid and lead nitrate form nitric acid and lead sulfate. The dense white fumes indicate that all the nitric acid has been driven off. Lead sulfate is insoluble in water and forms a white precipitate.

P. 20. The solution is made basic for two reasons. First, sulfides of iron and zinc can be precipitated readily only from neutral or basic solutions. Second, aluminum and chromium do not form sulfides in the presence of water because their hydroxides are weak bases and their sulfides are hydrolyzed at once to hydroxides which are insoluble. Ammonium chloride must be added to prevent the precipitation of magnesium hydroxide. This is very insoluble in water, but dissolves readily in solutions of ammonium salts.

P. 21. Hydrochloric acid forms soluble chlorides of the metals. When sodium hydroxide is added, ferrous, aluminum, chromium, and zinc hydroxides are formed. The last three are amphoteric and react with an excess of base to form soluble

salts while ferrous hydroxide remains insoluble. The following reactions are typical:

$$ZnCl_2+2NaOH\rightarrow Zn(OH)_2+2NaCl$$
$$Zn(OH)_2+2NaOH\rightarrow Na_2ZnO_2+2H_2O.$$

Sodium perioxide is a powerful oxidizing agent. It oxidizes ferrous hydroxide to ferric hydroxide, and sodium chromite to the chromate.

$$Na_2O_2+2Fe(OH)_2+2H_2O\rightarrow 2Fe(OH)_3+2NaOH$$
$$3Na_2O_2+2NaCrO_2+2H_2O\rightarrow 2Na_2CrO_4+4NaOH.$$

It is necessary to boil the solution to decompose the excess peroxide. If it is not completely decomposed it will reduce sodium chromate back to the chromite when it is acidified in P. 23.

P. 22. $FeCl_3+6KSCN\rightarrow 3KCl+K_3Fe(SCN)_6$.

P. 23. Hydrochloric acid changes sodium zincate and sodium aluminate to the chlorides of the metals.

$$Na_2ZnO_2+4HCl\rightarrow 2NaCl+ZnCl_2+2H_2O$$
$$NaAlO_2+4HCl\rightarrow NaCl+AlCl_3+2H_2O.$$

Addition of ammonia water causes aluminum hydroxide to precipitate. Although you might expect zinc hydroxide to precipitate also, it does not because zinc hydroxide reacts with ammonia to form a soluble complex compound, $Zn(NH_3)_4(OH)_2$.

P. 24. The complex zinc compound is stable only in an excess of ammonia. When the solution is acidified with acetic acid, zinc acetate is formed.

P. 25. A faint white cloudiness due to free sulfur may appear if hydrogen sulfide is added for longer than 1 minute, because hydrogen sulfide is slowly oxidized by oxygen of the air. If you are in doubt about the test, acidify a small portion of the solution with hydrochloric acid. Zinc sulfide will dissolve, sulfur will not.

P. 27. Scratching the inside of the tube causes magnesium ammonium phosphate to precipitate. Although it is very insoluble it readily forms a supersaturated solution, and scratching the tube is a good way to cause crystallization to start.

The world is entitled to good children, but we cannot have good children unless we have good parents, good teachers, good schools and a sense of social responsibility to the children who are here and to those who are to come.—JACOB PANKEN.

MATHEMATICAL INDUCTION IN HIGH SCHOOL TRIGONOMETRY

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Several different types of proofs have been evolved for the "addition formulas" of plane trigonometry. I have tried presenting these proofs in high school classes as an application of mathematical induction. Many a student comes to trigonometry from an advanced algebra course without ever having heard of mathematical induction. Consequently, we have here an excellent opportunity to introduce him to something which is new to him, presenting mathematical induction from the beginning in one or two preliminary algebraic lessons and then developing these formulas as an application of the method to trigonometry.

The complete proof consists of showing that since $\sin x \cos y + \cos x \sin y$ is the sine of $(x+y)$ in *any* one quadrant, then it is also $\sin (x+y)$ in the *next higher* quadrant, and hence the relation holds true in *any* quadrant and thus for all angles. The steps of the induction in order are:

1. Show that the formula

$$\sin (x+y) = \sin x \cos y + \cos x \sin y \qquad (1)$$

holds when x and y are both acute and $(x+y)$ is either acute or obtuse.

2. Assume (1) holds for a certain pair of angles x and y, and show that

$$\sin (x'+y) = \sin x' \cos y + \cos x' \sin y$$

where $x' = (x+90)$.

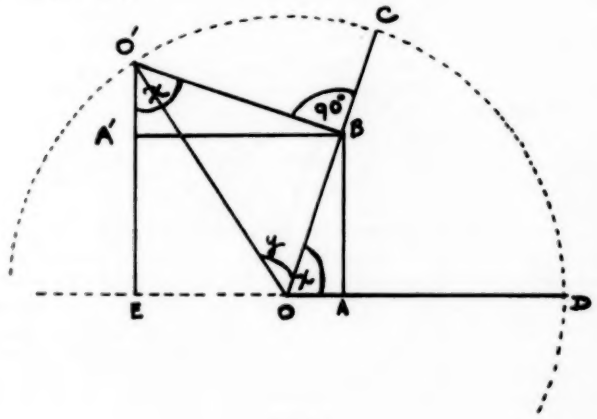

FIG. 1

The first of these steps (using Fig. 1) is given in detail in practically every trigonometry text. The details of the remaining step is as follows:

(a) *Replace x by x' in* (1), *where* $x' = (x+90)$.

This gives $\sin(x+90+y) = \sin(x+90)\cos y + \cos(x+90)\sin y$

or, $\sin(x'+y) = \sin x' \cos y + \cos x' \sin y.$ (2)

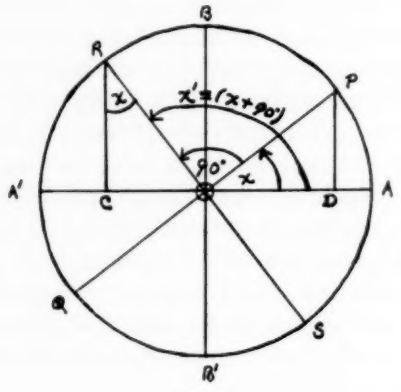

FIG. 2

(b) *Show that we can get the result in* (2) *directly from a figure and without substituting in* (1).

In the unit-circle of Fig. 2, PQ and RS are perpendicular diameters, and PD and RC are each perpendicular to $A'A$. Then in the congruent triangles DPO and OCR:

$$\sin x = DP = -OC = -\cos(x+90) = -\cos x' \quad (3)$$

$$\cos x = OD = CR = \sin(x+90) = \sin x'. \quad (4)$$

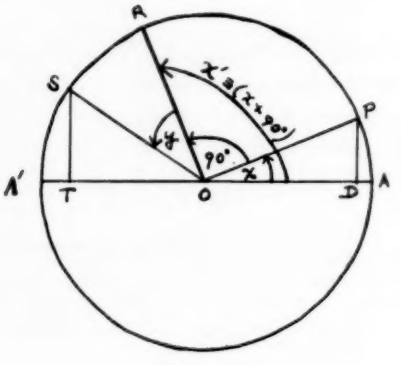

FIG. 3

In the unit-circle of Fig. 3:

$\angle DOR = x' = (x+90)$; if $\alpha \equiv (x+y)$, then

$$\begin{aligned}\sin \angle DOS &= \sin (x'+y) = ST = \sin (90+x+y) = \sin (90+\overline{x+y}) \\ &= \sin (90+\alpha) = \cos \alpha = \cos (x+y) \\ &= \cos x \cos y - \sin x \sin y \text{ (to have been previously proved)} \\ &= \sin x' \cos y + \cos x' \sin y \qquad \text{from (3) and (4).}\end{aligned}$$

We know formula (1) is true if x and y are any two positive acute angles. Then because (2) is true, (1) is true if x is an angle of the second quadrant and y in the first, and so on for all angles.

This method of deriving the formulas is not new (*e.g.*, see Wilcynski and Slaught *Plane Trigonometry*, 1914), but the new thing, if it be new, is the presentation of this method to high school students. Pupils who like something "different" enjoy this method of presentation, and feel that they are learning something new, more so than if the proofs are given by methods familiar to them since plane geometry days.

NEW KODACHROME SLIDE SERIES AVAILABLE

The Department of Education of the American Museum of Natural History has just made available to schools and colleges the first teaching series of Kodachrome lantern slides to be offered by any institution. The "Evolution of the Horse" is the title of this set of twenty-five slides made up in the increasingly popular 2×2 inch size, bound in glass, priced at $15.00.

Dr. Walter Granger, famous palaeontologist at the American Museum, has endorsed the accuracy and fidelity of the slides which are reproductions of exhibits in the museum.

A process of duplicating Kodachrome pictures has been developed by the museum so that careful control of the color of the final slide is maintained. The original photographs of the exhibits are made on the larger Kodachrome sizes so as to retain as much detail as possible. These large pictures are then rephotographed down to the thirty-five millimeter size using an artificial light source accurately adjusted as to color temperature. A complete series of faint complementary color correction filters makes it possible to adjust the hues of the final slides to as close a duplicate of the original colors in the museum exhibits as is necessary to maintain fidelity.

The "Evolution of the Horse" series contains maps of the chief fossil deposits in the United States, pictures of the formations in which the fossils are found, a progressive series of the fossil horse skeletons, Charles R. Knight's famous paintings of restorations of the fossil horses, and the contemporary life of each period. Slides comparing the skulls, hooves, and overall size of the earliest and modern horses complete this unusual series. A special manuscript has been written describing the slides and the story of "The Evolution of the Horse."

This set of slides is the first of several series which have been planned. The Story of the Dinosaur and Ancient Man will follow soon. The "Evolution of the Horse" is already in use in the high schools of New York City.

TREND OF EMPHASIS ON SCIENCE SUBJECTS IN TENNESSEE ACCREDITED SECONDARY SCHOOLS

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The field of science[1] is on the increase in Tennessee accredited high schools as shown by a study of offerings and participations. In the present study tabulations were made from 564, or 89.57%, complete Annual High School Principal's Reports for 1930–31 and for 483, or 80.40%, complete Reports for 1939–40. The percentage of the total number of units which were included in the field of science for both years indicates the change of position of that field in the entire program of studies from the standpoint of offerings. Likewise, the number of pupils pursuing units in science in relation to the total number of pupils pursuing units in the various fields indicates the changing position of science from the standpoint of pupil participation.

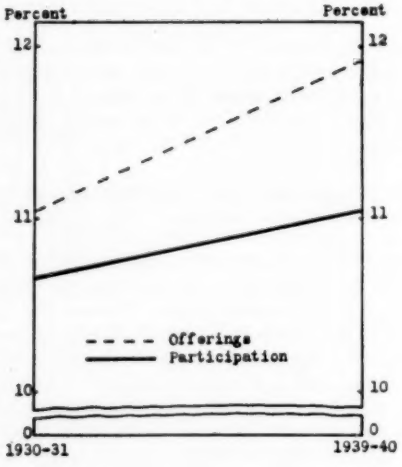


FIG. 1. Trend of emphasis on science in accredited secondary schools of Tennessee as shown by offerings and by participation, 1930–31 through 1939–40.

In 1930–31 science claimed, on the whole, 10.59% of the total offerings in the accredited high schools of Tennessee. By 1939–40 the figure had changed to 11.03% of the total. Considering

[1] Including general science, biology, chemistry, physics, physiology, senior science, botany, and zoology.

the number of pupils pursuing units in the various subjects, science drew 11.29% of the total in 1930–31 and 11.97% of the total in 1939–40. The field of science, then, assumed an increasingly prominent place in the program of studies during the ten-year period. It is significant that the percentage of pupils participating in science showed a more rapid gain than did the percentage of the total offerings included within the field. Figure 1 shows in graphic form the trend of emphasis on science in Tennessee accredited high schools as indicated by offerings and by participations.

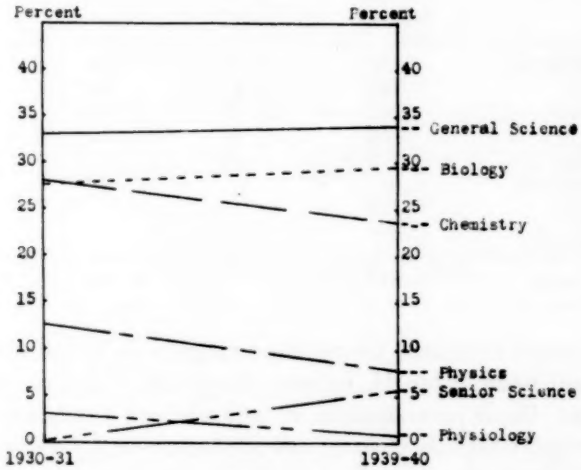


FIG. 2. Trend of emphasis on science subjects in accredited secondary schools of Tennessee as shown by offerings, 1930–31 through 1939–40.*

* Botany and zoology offered so infrequently in both years that they are not included in the Figure. See Table 1.

Though the field of science as a whole gained in prominence, that is not true for every subject within the field. The general gains and losses for each of the subjects from 1930–31 through 1939–40 as shown by offerings may be clearly noted in Figure 2 and the more exact changes are given in Table I. Gains were made by three science subjects, namely, general science, biology, and senior science. Losses occurred with respect to chemistry, physics, physiology, botany, and zoology. It appears that the three subjects of general science, biology, and senior science are rapidly replacing the five old-line subjects of chemistry, physics, physiology, botany, and zoology. The tendency is definitely in

the direction of "combination" subjects with perhaps a more humanizing influence intended. This trend has gone so far in some of the schools that senior science is now listed among the social studies.

TABLE I. NUMBER OF UNITS OFFERED IN EACH SCIENCE SUBJECT AND PERCENTAGE OF THE TOTAL NUMBER OFFERED IN THE ENTIRE FIELD OF SCIENCE IN ACCREDITED SECONDARY SCHOOLS OF TENNESSEE, 1930–31 THROUGH 1939–40

Subjects	1930–31		1939–40	
	Units Offered	% of Total	Units Offered	% of Total
General Science	336	33.15	402	33.81
Biology	280	27.63	352	29.60
Chemistry	261	25.75	282	23.72
Physics	130	12.83	91	7.65
Physiology	5.5	.54	1	.08
Senior Science	—	—	60	5.05
Botany	1	.10	.5	.04
Zoology	—	—	.5	.04
Totals	1,013.5		1,189	

The trend indicated by pupil participation, as seen from Figure 3 and from Table II, follows closely the trend as shown by offerings. Pupil participation in physics and chemistry has decreased more rapidly than school authorities have dropped those subjects from the course of study. On the other hand, pupils have not been so eager to participate in senior science as school authorities have been to add the subject. The tendency to consolidate science subjects is at variance with the findings of several prominent earlier studies, such as those by Roemer[2] and by Counts,[3] which stress the tendency to add courses more rapidly than they are dropped. Such is not the case in the field of science, at least, in the accredited secondary schools of Tennessee. Instead, the tendency is in the direction of the consolidation of courses such as that suggested by Professor Judd in 1932 when he said:

> I believe we can reorganize instruction in high schools and colleges so as to provide more compact and therefore more useful courses. I venture the

[2] Joseph Roemer, "Secondary Schools of the Southern Association," *U. S. Bureau of Education Bulletin*, 1928, No. 16, pp. 62–65.

[3] George S. Counts, "The Foundations and Technique of Curriculum Construction," *Twenty-Sixth Yearbook*, National Society for the Study of Education, 1927, p. 139.

rough estimate that the two hundred and fifty subjects now taught in the high schools of United States can be reorganized into some ninety or a hundred substantial courses.[4]

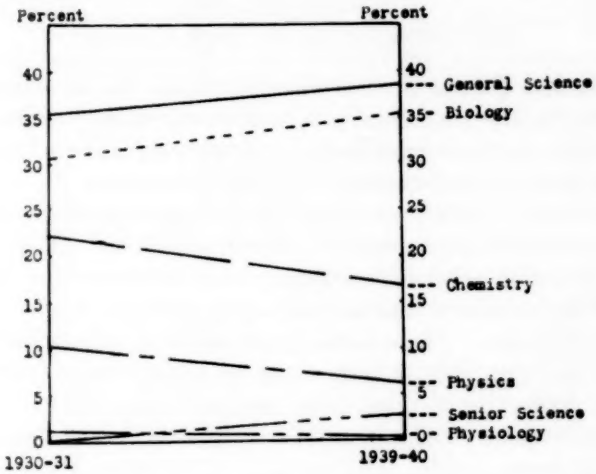


FIG. 3. Trend of emphasis on science subjects in accredited secondary schools of Tennessee as shown by participations, 1930–31 through 1939–40.*

* For botany and zoology see Table II.

TABLE II. NUMBER OF PUPILS PURSUING UNITS IN EACH SCIENCE SUBJECT AND PERCENTAGE FOR EACH SUBJECT IN RELATION TO THE TOTAL PARTICIPATION IN THE ENTIRE FIELD OF SCIENCE, ACCREDITED SECONDARY SCHOOLS OF TENNESSEE, 1930–31 THROUGH 1939–40

Subjects	1930–31		1939–40	
	Pupil-Units Pursued*	% of Total	Pupil-Units Pursued*	% of Total
General Science	8,878	35.69	17,617	38.50
Biology	7,628	30.67	16,021	35.01
Chemistry	5,502	22.12	7,774	16.99
Physics	2,575	10.35	2,884	6.30
Physiology	240	.96	6	.01
Senior Science	—	—	1,313	2.87
Botany	50	.20	62	.14
Zoology	—	—	79	.17
Totals	24,873		45,756	

* Pupil-unit is used in the sense of one Carnegie unit of work pursued by one pupil.

[4] Charles H. Judd, "Education, The Nation's Safeguard," *Official Report*, Department of Superintendence, 1932, p. 40.

CHILD INTERESTS IN CURRICULUM BUILDING*

GRACE S. NUGENT
State Teachers College, St. Cloud, Minnesota

In the last decade since science has begun to be of some importance in the elementary school curriculum, teachers and builders of curricula have been a bit confused as to what should constitute both good content and good placement.

If you have examined many so-called courses of study in science you will find a predominance of projects on plant, animal life and health with a smattering of astronomy and physics, very little chemistry and scarcely any geology.

Now just why? These other fields touch a child's life just as closely and are just as interesting as those which curriculum makers have thrust upon him. Because that is exactly what they have done. Without any investigation in the direction of child interests, adults, and usually adults who know nothing about children, take it upon themselves to dictate what they imagine children ought to have and like.

Wouldn't you think that scientists, of all people, would have profited by the blunders made in other fields? For example take the field of literature. Do you remember the trite, uninteresting, moralizing stories and poems in particular that we read as children? Very definitely they were the products of adults who were sincerely making a conscientious effort to write in a field about which they knew nothing. They were interested in teaching skills and tools but the child interest element was entirely ignored. One has only to glance at the reading table in any school or library today to see what a marvelous improvement has taken place. Books are written today about things that interest children. They are beautifully illustrated and fascinating to read. This revolution was brought about merely by changing the viewpoint of the writers.

It seems to me that scientists have reached the place in curriculum building where they are going to have to change their point of view. Instead of forcing all children regardless of environment, background, native ability, interest and special aptitudes through the same gateway, the field of science lends itself better possibly than any other to the satisfying of the child's natural curiosity and specific needs.

* Presented at Meeting of American Nature Study Society, Philadelphia, December, 1940.

To accomplish this evolutionary viewpoint the science specialist will have to recognize the fact that he is not capable of doing the job alone. Much as he may hate to acknowledge it, the person who can help him most is the one whom he has persistently ignored; namely, the elementary school teacher. In fact she has always been ignored whether rural or urban by the architect who builds her laboratory, by the administration who hires her, by the curriculum makers who cut out her job and by the textbook writers who furnish materials. None of these experts ever ask the advice of the one person who is closest to the core of it all. There has been too much talk about the child centered school by the same people who have been guilty of placing insurmountable stumbling blocks in the path of the one who is to direct it. It is about time that the elementary teacher came into her own and is recognized for what she is—a practical specialist in child life.

How would one go about building a curriculum with child interests as the core?

First of all I suggest a committee composed of science specialists from every field. I should like each of these people to be more than an encyclopedia of scientific data. Each must be sincerely interested in the job he undertakes; namely, to select from his field those items that touch a child's life closely and an understanding of which will enrich his living and help him to appreciate more fully the natural phenomena surrounding him. Secondly, each must have a truly scientific viewpoint, free from selfish motives.

After the committee has been found, a like number of master elementary teachers should be located. These teachers must have done some experimenting with children's interests in science and be thoroughly imbued with the idea that children should have a hand in planning their own science job. These two groups working together over a period of time should be able to collect enough data through research and experimentation to make a fairly valid list of children's interests. Then, these lists need to be turned over to the master teachers all over the country; rural, urban, and experimental. It will be the job of this group to work out units with the children, setting up their finished experiments in a report to the head committee. This report should include problems solved under each unit, activities and experiments used in solving these problems, other possible activities, outcomes of the unit and a list of materials used.

It will be the job of the head committee to examine these reports and from their findings, set up sample units in each field with long lists of possible activities and experiments and a children's bibliography for each. These are not to be sent out to be followed exactly by teachers all over the country, but are to be suggestive for the inexperienced teacher with no or little science training. These teachers have to have guidance and assistance the ultra progressive school of thought not withstanding.

One of the first things that will come to the attention of the head committee is the fact that there are very few books, magazines or pamphlets except in a few subjects that children can read. In my own experience with fourth grade children I am constantly confronted with the problem of finding materials that will make it possible for them to pursue their own interests. This is in a school where we are fortunate enough to have a fine library too. Some of the materials we do find are sketchy and vague and do not answer the questions that children ask at all. A few of these interests for which we found good materials lacking are water insects, galls, flowering trees, weeds, dogs, cats, calves, horses, mosses and lichens, game fish, and garden pests.

The best materials we found were books at the college level. Some of these were written simply and contained interesting material. Children prefer these to many of the books on their own level because they are factual and not full of useless conversation. Children loathe books that indicate any condescension on the part of the writer. Too much explanation is an insult to their intelligence. Science is interesting enough in itself so that it needs no dressing up to be sold to children.

Writing for children in the science field has been scarcely touched. Too much liberty has been taken by publishing companies and textbook writers who have had the field to themselves and have gone on writing and publishing books pretty much in the same pattern, and superintendents have been buying them. Both producer and buyer in this case have been quite honest and sincere in thinking that they were producing and buying the best on the market. Furthermore, scientists have aided and abetted them in this by writing along the dictated pattern merely to sell a book. Now it is time to get back to the consumer of this knowledge, the child. It is time for the scientist to stop being satisfied with merely writing and selling a book. He must write for the use of children and to fulfill specific

needs and he must have definite practical research back of everything he does. He must write with children's questions in mind. He must write simply, directly, sincerely, and interestingly. His books should be well illustrated with actual photographs when possible and simple sketches when not. The vocabulary must be simple but necessary scientific terms should not be avoided but used naturally. Children love big words when they know what they mean. He should include a great deal of interesting material on the habits, care, economic value and control in his wildlife stories. In other words here again the scientist and the elementary teacher must work together to be sure that the product will answer the need that gave it birth.

Further, this material must be produced as cheaply as possible so that it can be available to all children even in poverty stricken districts. Several companies have proved that it can be done as is shown by some of the excellent material both in social studies and science that is on sale in the dime stores. Put out on a large scale in individual booklet or pamphlet form would make it possible for each school to purchase those unit studies that would satisfy their own needs as they arose. As textbooks are written now, much material goes begging because of lack of need or interest while the school is handicapped by being able to purchase only one book and then use that until it is completely worn out.

If this material is written simply, there is no need for the curriculum builders to worry about placement. I have watched kindergarten children listen delightedly to stories that intermediate grade children will read by themselves with interest. By the same token, junior high school children will read fourth grade material providing it is not so labeled and that it answers some definite need. Provide children with material they can read, see that it is rich in content, vivid in portrayal and let the children do the rest.

How shall we train teachers to handle this job? In the first place with simple readable material available for children, she will be relieved of trying to make herself into a fountain of knowledge as she tries to do now and can spend her time learning more about ways and means. No human being in one short lifetime can possibly be an expert in all lines as is expected of the elementary teacher. Science in many schools has been neglected for this very reason. She is afraid of it. With this suggested setup she can learn along with the children and science will be a

happy experience for all concerned. In the second place, science classes in both teacher training institutions and universities are sadly in need of revision. There needs to be a definite difference in content and organization of classes destined for different needs. The research student who will specialize in a definite field will need a much different preparatory background from the elementary teacher who will have to spread her time pretty thin over a great number of fields. Time must be conserved for her by the people who plan her courses. She should not be required to spend a whole semester dissecting a frog to learn anatomy or counting Drosophila to learn the principles of genetics. Both of these are fine courses for those who need them but the elementary teacher's crying need is much different. She needs to know what children like, what experiments and activities she can use to prove points, what materials are available and best for her purpose, and most important of all, she needs to be taught how to direct children in becoming independent students in their own interests. This is the job for scientists and so far they have failed sadly in this phase of it.

This group is confronted with one of the most stimulating challenges of all time, teeming with possibilities, limitless in scope, rich in content and so very needful. It is time for us to stop burrowing mole-like toward the light, each in his own dark tunnel. The best contributions for mankind need the best efforts of many working together. Start with the child and his interests, prepare material for his needs, train his teachers to direct him efficiently, and millions of children and their teachers will rise up and call you blessed.

AMENDMENT PROPOSED

The change in the date of Thanksgiving during the last few years has created a problem. Section 1a of Article II of the By-Laws of the Central Association of Science and Mathematics Teachers states:

"ANNUAL MEETINGS: The Annual Meeting shall be held on the second day after the last Thursday in November of each year."

Mr. Glenn Hewitt proposed the following amendment, which was approved by the Executive Committee. It will be printed in the two Journals previous to the 1941 Convention, and voted on at the time of the Convention.

"TIME OF MEETINGS: (a) ANNUAL BUSINESS MEETING: The annual business meeting shall be held on the second day after the date proclaimed by the President of the United States as Thanksgiving Day of each year, or on such other date in November as the Board of Directors may prescribe."

THE PLACE OF THE ITINERANT SUMMER SESSION SCIENCE TEACHER IN NATIONAL DEFENSE*

R. A. WALDRON
State Teachers College, Slippery Rock, Pennsylvania

There is something in every man's life that the army, therefore our national defense program, needs. It may be some particular skill, it may be knowledge, or it may be research. Problems are continually arising, and the scientist is looked to for an answer. Except for those who can be trained to do nothing else the day of the gun toter is past, whether in the army or any other branch of society. This is the day of technicians, with training in skills and more skills.

In presenting a paper on this subject there are no problems that the non-travelling science teacher could not undertake. Emphasis is here made that those who "travel about" obtain perspectives that enable them to understand more fully the various places, problems, and situations needed for coordination, teamwork and administration. The Germans seem to understand this. Three years ago, when the writer had a party of college students on a geological study tour at the Niagara Falls region, there were at the same hotel thirty or forty young Germans being conducted about the industries so numerous there. How valuable may these picked youths become to their country, if our country is invaded? And who can say it cannot be invaded? There are numerous individuals who travel, however, and gain much valuable knowledge, who do not have what it takes to lead in national defense. The responsibility of selection belongs to those in charge of appointments. In this connection the writer, during the first World War, was sent to various grain growing centers to bring about greater wheat production by farmers through seed treatment to prevent wheat smut diseases. Youth and inexperience in handling people were a handicap. Attempts were made to get in direct contact with the farmers, but much more could have been done in assembling the growers with the help of well known local leaders such as county agricultural agents. It should be emphasized that just because some have travelled, it does not assure success in leadership for national defense or in anything else.

* Presented at meeting of American Nature Study Society, Philadelphia, December, 1940.

Just who are these itinerant summer session science teachers? They may be of either sex, they may be grade or high school teachers, or they may be college instructers. There are some who do not even teach science as such, but who are interested and more or less trained in some of its branches. County agricultural agents as well as the many high school agricultural teachers should not be omitted in the complete picture of the problem. Again, there will be a man or woman here and there, not teaching but whose travel, training, and hobby are scientific and who can usually be found through local high school or county agents. All these named groups have among them individuals who would be leaders and those who would not be. The county agents and high school agricultural teachers mentioned are themselves locally itinerant science men who know the economic, or farming, problems, over a certain area, and who pretty well understand their possible resources. They could direct the production of quick growing products, knowing what could be planted and where it could be successfully raised.

All units of society from "dirt diggers" to "fact getters" have services of value which are all calling for more exacting technique. The following is a list of such services which the travelling summer school teacher might offer. The list is probably far from complete but if it offers suggestions and stimulates interest it will have served its purpose.

TYPES OF SERVICE

A. Surveys of fauna and flora for poisonous plants and animals is vital. Boys in CCC camps of Pennsylvania were killed when they ate the fleshy roots of cicuta. There are many common plants that are poisonous to eat, at least certain parts or stages. Muencher* and others have given us guides. A sergeant in our present army tells me that a unit was sent into a certain part of Texas where several casualties occurred from snake bite. After that all proposed encampments were given a preliminary flora and fauna survey before camp was established. There are several plants beside the well known poison ivy that cause skin disturbances. These should be known and avoided by all. Who is better fitted to take up this work than the summer biologist? A number of excursions have been organized and conducted by field men who have trained the members of their groups in field work in various parts of the country. Such surveys as this will

* Muencher, *Poisonous Plants of the United States*, Macmillan (1939).

be of value to the non military public as well as to the army.

Not only this, but surveys of food and food substitutes can be of value. A recent notation in *Science* shows the value in England of oak acorns and horse chestnuts as food for livestock in place of important grains. Pigs, it is stated, are the only animals to refuse them. Many rare yet edible plants, such as medeola, should be used with caution so they will not be destroyed.

Many surveys have been made, but there are few men able to locate useful materials (except lumber and minerals) in reasonable quantity to be of much use. The trained forester and geologist have developed these latter. Many summer science teachers are sufficiently trained in field work to fill in the gaps. A particularly useful product (not food or poison) is sphagnum moss, which was a substitute in World War I for cotton.

B. Surveys of land and geological formations as safe recreational centers, as sources of safe water, and as places of influx from cities in case of bombing is necessary. Although the army has its water purification units much more could be done in the way of knowledge of all these and related factors to care for the health and morale of the public. Many Britishers would be better off at present if they knew more bacteriology and parasitology.

There are many city folks who go to the country, but their knowledge stops with a few facts about swimming, fishing, and hunting. Here are groups (hunters and fishermen) through whom much could be done. There is much of value in both peace and war in someone knowing all the valleys, mountains, streams, springs, rock strata, plants and animals of certain areas. The U. S. geological survey has done much, but much is yet to be done. The Greek successes against the Italians may be due in part to such complete knowledge.

C. Another service besides that of surveys is that of developing the moral and scientific attitude. The philosophy of accepting what cannot be changed is something that too few of the general public possess. The man who has been into Mexico knows that certain ways of being, eating and life in general differ greatly and must be accepted. Also, climatic conditions are unchangeable. If those in charge of the navy at Newport, R. I. during World War I, had ever been to Louisiana they would not have put new recruits from New Orleans on guard duty in zero weather which possibly caused pneumonia and possibly death. This last statement was given to me by a mem-

ber of the Newport naval outfit at that time. This understanding is necessary not only in the army but elsewhere. Avoiding mistakes, developing the scientific attitude and skills, developing the morale so well demonstrated in England today, all are services as valuable as surveys.

D. Another service is that of teaching—teaching those who defend and those who do not. The fun of knowing, the fun of hobbies, and the fun of being skilled in one thing are all worthy and essential phases of the whole problem. The army supplies recreational equipment. Why not also supply the opportunity for learning through nature, travel, technical skill in photography, and so forth? The summer science teacher could do much here for both the army and the public. The army needs the highest of skills in all these lines.

In this emergency, and it is a real one in spite of the fact that that many people are not awake to it, everyone must prepare and be ready in his particular ability to help. Those who have travelled have much of value to the rest. Let some central agency such as the state, list the needs of defense, and then use those who can get in contact with many who are not within reach of any other service group. Some will be selected to travel far, some to travel locally.

There are many itinerant science teachers whose possible services are not realized by themselves or by others. They have teaching ability, knowledge of resources of various places, and have had social contacts in different states and countries. Perhaps this paper is a bit optimistic, but the writer feels that there is something being lost which should be salvaged. The traveller learns and develops skills in safety, food, and morale. This will not only be an aid in developing reasonable national defense program, but after the emergency is over, there will be gains for a better future for all. It is hoped that, if this paper has done nothing else, it will have helped to clarify the problem.

The present period calls upon us to face the facts—to know what is going on—and realistically to sound the depths of our abilities to contribute to the strength of a united national effort. Never has there been a time when the need has been greater for wholehearted cooperation upon the part of all groups and individuals. Education, together with industry and labor, must face the issue squarely for the preservation and improvement of the basic and enduring ideals of democracy. There can be no other course for America.—*Floyd W. Reeves, Director, American Youth Commission.*

HOW A PHYSICS CLASS SOLVED A PROBLEM

R. E. SHOWERS
East High School, Green Bay, Wisconsin

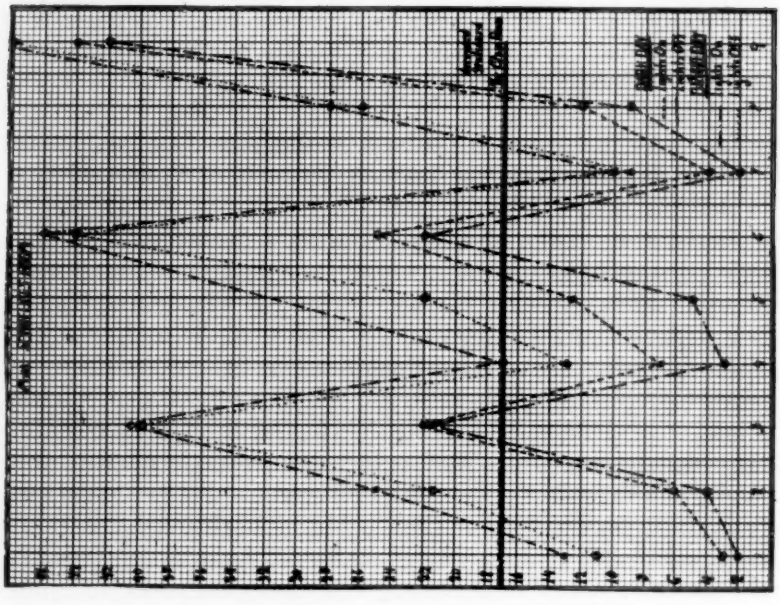
Last year there was a problem in our school of inadequate lighting. In this article the discovery, attack, and pupil solution of that problem will be discussed.

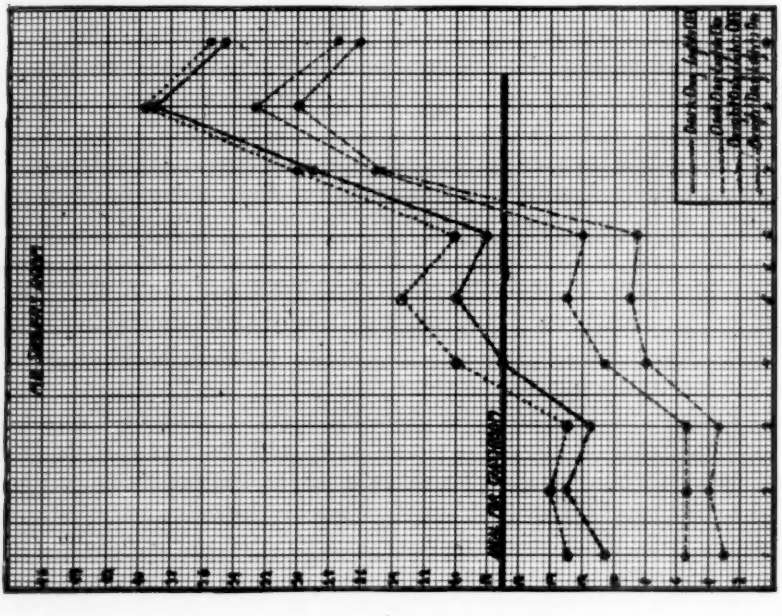
Realization of the need arose during a discussion of proper lighting standards for study. Some of the pupils had found reading difficult in the science room. This room was lighted by two semi-indirect lamps suspended by chains in the middle of the room. In discussing whether this room was lighted satisfactorily the senior physics class began to consider whether or not the school as a whole had adequate lighting facilities. This question tapped a reservoir of school spirit. Innumerable queries were made, and to settle the controversial opinions the group decided to perform an experiment that would be both reliable and authoritative.

Since there were no attendant laboratory exercises or equipment with the course, the problem of correct "write ups" was first to be attacked. The class spent a day studying forms of experimental records. A general form was agreed upon for recording data and composing the body of the experiment. The next step required provision of equipment. Meter sticks were available but the school did not possess a photometer. Arrangements were made to borrow one.

The pupils worked in groups while collecting data. Measurements were taken of each room, and a floor and window plan were made for each. Points for photometer readings were marked on the floor. The points were numbered for each room and the photometer readings taken at desk height and recorded after the numbers. Four readings were taken for each room. Dark days and bright days with lights on and lights off were considered adequate.

Each pupil then took the data for a single room and wrote a report. Each of these individual room reports was read to the class as a whole which criticized the method of presentation and the conclusions drawn. After the class criticism and suggestions were made, the corrections were incorporated in the report. The augmented reports were then revised by a reviewing committee of five students selected by the class. After progressing thus far in the work the pupils recognized the need for visualizing the





project. Two boys volunteered to make graphs of outcomes for each room. Each condition was graphed in broken lines using position as abscissas and intensity as ordinates with a straight line on the graph for recommended intensity. The text and numerous lighting pamphlets were used as references in the work.

An integral part of the project involved recommendations for needed changes in the lighting system. These changes were included in the final report which students in the class typed. A copy was submitted to the superintendent. This summer improvements were made in the system in an attempt to conserve sight.

For three weeks the project was a stimulating activity for a group which seldom could have laboratory work. While learning about illumination they arrived at certain outcomes which they ordinarily would never have developed. Some of these desirable outcomes should be pointed out. Direct results came in learning the need for accuracy of measurements and diagrams. The method of taking careful readings of instruments was learned as was the method of concise recording in a readable form of pertinent data. The proper use of the photo-electric cell of course was acquired, which some day may find use in reading of light meters for those interested in photography. Some indirect but vitally important results came in the cooperative spirit of the experiment. One phase of the scientific attitude was cultivated by the insistence on drawing conclusions only after all data were in. A real understanding of the law of inverse squares regarding light intensity as it is affected by distance of the illuminated object from the source of light was gained. The fact was emphasized in the final conclusion that the cheapest expedient for bettering the lighting was to lower each unit where possible. The class even worked out a simple problem to show the increase of intensity which would be obtained by lowering a lamp two feet. A concomitant of this realization was evident in discussions of home lighting systems of the pupils who then realized the optimum position of lights for proper illumination.

While arriving at the outcomes mentioned, the students experienced the reality of cooperatively attacking a mutual problem. Cooperative living seems to be one of the goals of democracy. Where better can we practice an application of such ideals to which we pay lip service than in the school system? In the school, with the aid of facts and equipment, why not let

students do some independent yet cooperative thinking and planning?

As teachers of physics we have often been open to criticism on the basis of being "fact" teachers. Sometimes we regretfully have to admit the truth of such criticism. The grades have long been dwelling on activity teaching and we have complacently sat by while the parade has swung along. Mere applications of our theories can not satisfy the growing surge of activity teaching. The problem is ours and the question is, "Can we handle it?" Our experiment offers something definite to the individual who expects concrete results from activity teaching. This group of students made a contribution to their school which can hardly be measured. To a certain degree they answered the challenge confronting physics classes. If more units could be handled in this way, we as science teachers could contribute as much or more to activity teaching as any group of educators. The possibilities are present if we only utilize them.

$5,200 GOES LONG WAY IN SIGMA XI AWARDS TO 33 SCIENTISTS FOR RESEARCH

Stretching $5,200 a long way, the Society of the Sigma Xi, national honor society for promoting scientific research, has made grants-in-aid to 33 scientists engaged in important research.

The grants, some as small as $50 and others as large as $300, will be spent by the scientists for much-needed equipment or in continuing laboratory experiments in medicine, astronomy, physiology, chemistry and other fields. Applications for the awards, which poured in from institutions scattered over the country, amounted to about $20,000, said Prof. George A. Baitsell of Yale, national secretary of Sigma Xi, announcing the decisions.

The committee which awarded the available funds consisted of Dr. Gary N. Calkins of Columbia University, Dr. Harlow Shapley of Harvard, and Dr. W. R. Whitney of the General Electric Research Laboratory.

Funds for the Sigma Xi grants-in-aid come from small contributions made by thousands of members of the national honor society throughout the country. Coming from this source, the financial aid is doubly valued by recipients, the society states.

NEW FREEZE-RESISTANT NEOPRENE ANNOUNCED

A new synthetic rubber, of the neoprene type, which combines the high cold-resistant powers of natural rubber with the oilproofness of neoprene was announced by D. F. Fraser and F. L. Yerzley of E. I. du Pont de Nemours and Company. Principal use for this material is expected to be in automobile and airplane engines, which have to operate at temperatures ranging from 40 to 70 degrees below zero Fahrenheit.

EASTERN ASSOCIATION OF PHYSICS TEACHERS

One Hundred Forty-Eighth Meeting
UNIVERSITY OF NEW HAMPSHIRE
Durham, New Hampshire
Saturday, May 24, 1941

Morning Program

10:30 Meeting of the Executive Committee.
10:45 Business Meeting.
11:15 Greetings of the University.
Dr. H. L. Howes, Professor of Physics and Head of the Department of Physics.
11:30 Diffraction of Light by Supersonic Waves.
Dr. G. K. Hartmann, Assistant Professor of Physics.
12:15 Sound Analysis.
Dr. H. H. Hall, Assistant Professor of Physics.
1:00 Luncheon.

Afternoon Program

2:15 Physics of Metals.
Dr. D. S. Eppelsheimer, Research Professor of Industrial Engineering and Acting Director of the Engineering Experiment Station.
3:15 Inspection of Laboratories and Campus.

The Eastern Association of Physics Teachers congratulates the University of New Hampshire on its Seventy-fifth Anniversary, and is very happy to participate in some small way in the activities marking this event. Our best wishes go out to Dr. Engellhardt, to the members of the faculty and to the student body for many more years of successful work and happiness.

BUSINESS MEETING

Sister M. Dafrose, O.P., Bishop McDonnell Memorial High School, 260 Eastern Parkway, Brooklyn, N.Y. was elected an associate member.

Report of Nominating Committee

President, John P. Brennan, High School, Somerville, Mass.
Vice-President, Clarence W. Lombard, High School, Hyde Park, Mass.
Secretary, Carl W. Staples, High School, Chelsea, Mass.
Treasurer, Preston W. Smith, 208 Harvard St., Dorchester, Mass.
Executive Committee:
Everett J. Ford, English High School, Boston, Mass.
Lawrence A. Howard, High School, East Boston, Mass.
Robert W. Perry, High School, Malden, Mass.

Respectfully submitted,
Burton L. Cushing
Lawrence A. Howard,
William W. Obear.

The above named were elected for the ensuing year.

NEW APPARATUS

A Split Second Stop Clock with Hand and Photo-electric Control

The stop clock exhibited by Mr. Edward B. Cooper of the Brookline High School is built around a Warren Telechron motor which rotates at

one revolution per second. The construction is such that the clock motor runs continually, the hand being connected to the motor by a slipping clutch which is electrically controlled either by a hand switch or by photo-electric cells. The clock is designed to operate by hand control alone, by photo-electric cell alone, or to start by one control and be stopped by the other. The manual control can be extended to a considerable distance from the clock by means of a three-wire cable and switch which can be attached.

Details of the design and data on the operation of the system will be presented in an article now in preparation.

Among many uses of the clock are the timing of falling bodies, obtaining thereby not only time elapsed from start to stop, but also time elapsing between any two points on the path; obtaining nervous reaction time; timing moving vehicles in a very short distance; measuring the velocity of sound.

DIFFRACTION OF LIGHT BY SOUND WAVES

Abstract of Address by DR. G. K. HARTMANN

The human ear can hear up to at least 20,000 vibrations. As age increases the limit goes down probably to 15,000 cycles. The Galton whistle for relatively high frequencies is still audible. By means of a more elaborate whistle, sounds up to 67 kilocycles may be obtained. Supersonic research was limited by the sources available until means employed in connection with submarine work gave better sources.

Longevin in 1918 made use of a piezo-electric device, while Pierce in 1925–26 used the sharp resonance of quartz to control the frequency of electrical oscillations. It was found that vibrating quartz in air sent vibrations in air that could be detected in the glass of the oscillograph. Since that time there has been more interest in the subject.

Wood studied the effects of high intensity sounds of these high frequencies. Some of the effects were found to be:

1. Coagulation of smokes and clouds.
2. Production of very fine grain emulsions.
3. The energy of the sound beams goes into heating the medium, and its intensity can be measured by the rise in temperature of the medium.
4. Increase in the rate of mixing and the reaction rate of chemical changes.
5. Lethal effect on bacteria. Investigations were also made on tumors, and with cancerous mice. Filaments of spryogyra were torn and killed. Small fish were killed but mice were less sensitive. They could still move after twenty minutes and recovered rather rapidly.

The oscillator Wood described was a powerful 2 kilowatt instrument specially built by General Electric. It made use of a quartz crystal 3 millimeters thick. The static displacement constant for quartz was .0008 millimeters, the maximum velocity, 5 meters per second at 1 meg., and the acceleration 20,000 km. per second per second. (In 10 seconds, 10 meters away.)

Diffraction of light by sound was discovered 10 years after Brillouin

wrote a paper on the subject in 1922. In 1932 it was tried by Delige and Sears at Harvard, and Lucas and Biquard in Paris.

Light is sent through a slit and lens, then through a container or cell having a vibrating quartz crystal at the top so arranged as to send waves down through the container. A lens on the other side brought the light to a screen where a diffraction pattern was formed similar to that produced by a grating. Instead of air the cell may be filled with carbon tetrachloride. This substance is non-conducting, hence does not short circuit the crystal, and is also non-inflammable.

The position of the lines produced agreed with the grating formula:

$$\Lambda \sin \theta_1 = k\lambda.$$

The similarity with the grating stops with the formula, however.

Properties

1. If the angle of incidence of the beam is changed so that the light is not coming perpendicular to the sound waves, the orders disappear. This happens if a change of 2 degrees from the perpendicular occurs. This disappearance with change of the angle of incidence has to be explained.
2. Moving grating, Doppler effect. $V \pm kN$.
3. Wandering of intensity of orders with sound intensity. The higher orders become brighter unexpectedly.
4. Depth of sound field.
5. Lucas amplitude theory and Roman's phase change theory were discussed.

Experiments were shown in which the slit was replaced by a card having three holes, pin-holes equally spaced, and also refraction through an aluminum prism.

SOUND ANALYSIS

Address by PROFESSOR H. H. HALL

Dr. H. H. Hall described methods of sound analysis. He explained that in connection with the problem of investigating musical instruments, especially violins, and attempting to determine whether or not there was any scientific basis for discrimination between old and modern instruments, methods of making tests were sought. His address was essentially the same as his first article on sound analysis in the *Journal of the Acoustical Society of America* for April, 1937.

See also the following references:

C. W. Hewlett, *Phys. Rev.* 35, 359 (1912)
D. C. Miller, *The Science of Musical Sounds*, Lecture 4, p. 92 (Macmillan)
B. Germansky, *Ann. d. Physik* 7, 453 (1930)
C. N. Hickman, *J. Acous. Soc. Am.* 6, 108 (1934)
O. H. Schuck, *Proc. I. R.* E. 22, 1295 (1934)

T. de Nemes, *Phil. Mag.* 18, 303 (1934) & *Arch. f. Elektrotechnik* 26, 403 (1932)
E. Freystedt, *Zeits. f. tech. Physik*, 16, 533 (1935)
H. H. Hall, *J. Acous. Soc. Am.* 7, 102 (1935)
E. Meyer, J., *J. Acous. Soc. Am.* 7, 88 (1935)
W. E. Kock, *J. Acous. Soc. Am.* 7, 56 (1935)
H. H. Hall, *J. Soc. Mot. Pict. Eng.* 27, 396 (1936)

PHYSICS OF METALS

Abstract of Address by DR. D. S. EPPELSHEIMER

Present engineering practice requires the teacher to emphasize the properties of solids differently than was the case 10 or 15 years ago. The uses to which solids are put has changed. The historical study of engineering material has contributed many new concepts.

Benjamin Thompson noticed heat in boring cannon. His experiments became the groundwork for Davy's experiments in 1799, doing away with the caloric theory.

In metal cutting, for instance, ignorance was profound. The art of how one metal cuts another is a very definite science, and large sums are involved in it.

Up to 4 or 5 years ago, the concept was that there was a lathe-tool, a tool-holder, and the chip, cooled by a liquid, curled up. Wear occurred at the base of the tool, and it was believed that the chip came off as indicated by the wear.

Physics was turned to for an explanation and the problem was partly solved. Photo-electric study showed a zone of maximum stress, shear forces combining, acting to remove this chip, and no void at the point of the tool or metal. Application of a simple electrical method has enabled engineering to evaluate the important property of how to cut a metal.

Elastic properties, friction, and temperature, are important. Physics is of great help to the machinist in solving the problem.

Dealing with solids, the average college physics or high school textbook gives little mention of solid textures; whether one crystal or many, if crystalline; whether a pure material or an alloy; whether an impure material or an alloy. Glasses, non-crystalline, supercooled liquids, and plastics, pure or aggregate, offer a great field for research, and have introduced many new problems. The field of plastics is in the same state that metals were in 1700. There should be new material in lectures. The metals form a wide and specific field. A few questions are: How do metals and alloys crystallize? By what method are they classified? In what state does nickel or monel metal exist? The physical nature may vary although the chemical nature may not differ a bit. Bragg's law and X-ray patterns give a three-way classification.

The method of classification of metals and alloys is evolved by studying

the space lattice arrangements of the atoms. The simplest arrangement is that having the atoms at the corners of a system of equal cubes closely packed. No metals or elements have this arrangement as far as is known. Examples of salts arranged in this manner are the alkali halides.

Metals are chiefly of three classes, the face-centered cubic space lattice, the body-centered cubic, and the hexagonal.

The first of these is the most common in the metals. In this the atoms are at the corners of closely packed cubes, as well as at the center of each cube face. Thus each atom has around it twelve equidistant atoms located symmetrically. This is characteristic of iron, gold, silver and copper.

The body-centered cubic arrangement consists of a unit cube structure having an atom at each corner and one at the center of the cube, the corner and center atoms being interchangeable. Each atom has about it eight equidistant atoms, also symmetrically situated. This type is not quite as closely packed as the face-centered and the hexagonal types.

In the hexagonal, the crystal is built up of a series of equal right-triangular prisms. The atoms are at the prism-corners and at alternate prism-centers. Each atom has around it twelve others equidistant, but not quite so symmetrically arranged. Zinc is a good example.

Metals having one space configuration tend to form alloys readily with other metals having the same configuration, but not so readily with those of different configuration.

Crystals do not behave alike. The physical properties vary in different crystal directions. The metals crystallize as we have seen in atomic arrangement (the lowest energy relationship that can exist for that metal). A molten pure metal is in a less stable state than the solid, and the X-ray diffraction of the liquid as it cools, shows energy spots built up in the liquid mass as it approaches the solid state.

Crystals form centers or nuclei for grains, which have a definite orientation in the final crystalline mass. The grains are crystals which have been compelled to fill all the available space, and due to crowding, may be distorted. The main axes of the grains do not all point in the same direction. If the metal is rolled the grains are brought more or less into the same direction, the properties of the metal being changed, since the properties differ in different crystal directions.

Austenite crystals (face-centered) may be grown of large size, showing that a definite pattern is built up. The tensile strength in the two directions differs. The modulus of elasticity of iron may be 48000.00 in one direction and 18000.00 in the other. Both are acceptable.

Another question has to do with the homogeneity of the metal. This is important in castings. Near the surface the metal may be solid, but further in, due to escape of gases or unsatisfactory atomic arrangement at the grain boundaries, there may be a zone of weakness. The atoms may be under a state of stress (an area of stress in the grain boundaries). The metal is more active chemically there, more susceptible to corrosion or vibrations. The metal may be a single crystal or there may be different sizes of grain struc-

ture. These things have an important effect on elasticity, yielding point, and ductility of metals.

Another problem of importance is how metals cool from the liquid to the solid state. In ordinary cooling we find a smooth down-curve to the freezing-point, where under-cooling may take place, and then a smooth down-curve again to thermal equilibrium.

If iron cools in this way, it reaches the freezing point and crystals form at 2,795°F. It then drops to 2,555° F. where the delta form, which is body-centered, results, and the curve straightens out slightly. As the temperature drops again, the arrangement changes into the allotrope known as gamma iron, which is face-centered. At 1,670°F. there is another thermal arrest and we have beta iron which seems to be body-centered and practically non-magnetic. At 1,415°F. there seems to be another small thermal arrest, and while the iron still retains the body-centered arrangement, it becomes magnetic, and its electrical properties increase. Without these changes it would be impossible to harden iron. It is one of the fundamentals, from a physical sense, in the study of a metal.

Other materials may be used in the laboratory to practice on.

Copper-nickel alloys are interesting. Since copper and nickel are similar metals, with almost the same atomic weights and volumes, and are both face-centered cubic in arrangement, it follows that their atoms are almost interchangeable in alloys. They are completely soluble one in the other, both in the liquid and solid states, and have only one liquid and one solid phase. These alloys solidify, not at constant temperature, but through a range of temperatures between the freeze-points of the two metals, and depending on the proportions of the metals present. The maximum tensile strength is at 70% nickel. Interesting problems are large grain structure, bands, tooling stresses, and twinning, distortions caused by crowding and slipping of crystals during solidification.

In a lead and zinc alloy of eutectic proportion one can come nearer to its composition by visual microscopic methods than the chemist can.

By etching, the crystalline orientation of the metal can be determined.

Cadmium and brass are good materials to study for twin patterns and structure.

Dr. Eppelsheimer showed samples of metals tested and broken by tension and shearing stresses, and showed graphs to illustrate the effect of cold-working on low carbon steel.

Other problems mentioned as worthy of study were creep of semi-viscous materials, and fatigue, damping capacities, and soil mechanics.

VITAMIN B_s

On September 16 Dr. Roger J. Williams of the University of Texas announced the discovery of á new vitamin in the B group. It is found in great abundance in leaves and hence is called folic acid.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON

State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the ones submitted in the best form will be used.

LATE SOLUTIONS

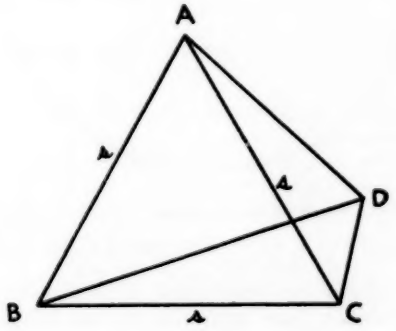
1709, 10. *Charles W. Trigg, Los Angeles, Calif.*

SOLUTION OF PROBLEMS

1711. This problem was incorrectly stated and hence no solutions were offered. It will be offered in a later issue.

1712. *Proposed by John P. Hoyt, Cornwall on Hudson, N. Y.*

If D is a point outside an equilateral triangle ABC so located that $DB = DA + DC$, show that angle $ADC = 120°$.



First Solution by Roy Wild, New Boston, Mo.

Let D be the required point
$\triangle ABC$ is equilateral and $DB = DA + DC$
Then $DB \cdot AC = DA \cdot BC + DC \cdot AB$
$\therefore ABCD$ is inscriptable by the converse of Ptolemy's Theorem
$\therefore \angle ADC = 180° - \angle ABC = 120°$.

Second Solution by C. W. Trigg, Los Angeles City College

Let the points be

$$A(-a\sqrt{3}, a), \qquad B(0, -2a), \qquad C(a\sqrt{3}, a),$$

and $D(x, y)$. Then since

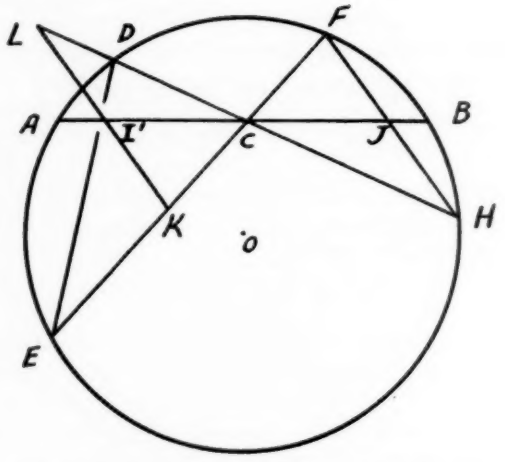
$$DB = DA + DC, \quad \sqrt{x^2+(y+2a)^2} = \sqrt{(x+a\sqrt{3})^2+(y-a)^2} + \sqrt{(x-a\sqrt{3})^2+(y-a)^2}.$$

When this equation is cleared of radicals and simplified, we have $3(x^2+y^2-4a^2)^2 = 0$. Hence D lies on the circle with center at the origin, radius of $2a$, and passing through A, B and C. It should be noted that the minor arc AC is the complete locus of D. Now the arcs AB, BC and AC are each 120°. Since angle ADC intercepts arc $AB+BC$, the angle is 120°.

Solutions were also offered by Aaron Buchman, Buffalo, New York; T. A. Pickett, Weymouth, Mass.; John P. Hoyt, Cornwall, New York; C. F. Holmes, Washington, D. C.; Gordon Durall, Cincinnati, Ohio.

1713. *Proposed by John P. Hoyt, Cornwall on Hudson, New York.*

AB is any chord of a circle. C is its midpoint. DH and FE are any two chords drawn through C. D and F lie in the minor arc subtended by AB. DE and FH are drawn intersecting AB at I and J respectively. Prove CI equals CJ.



Solution by Mannis Charosh, Brooklyn, N. Y.

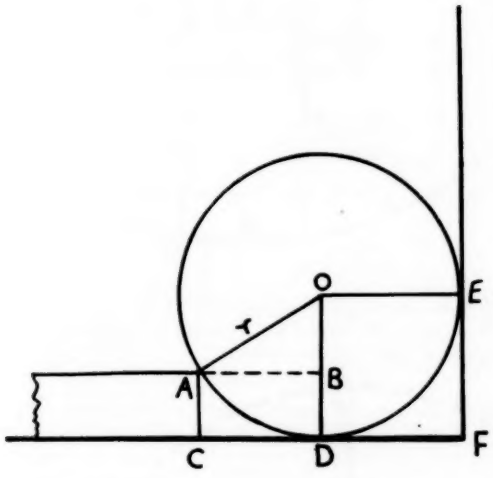
Take K on CE so that $CK = CF$; and extend CD to L so that $CL = CH$.
Then $\triangle CKL \cong \triangle CHF$, and $\angle L = \angle H$.
But $\angle E = \angle H$; therefore $\angle L = \angle E$.
Therefore points L, D, K, E are concyclic, and we will call their circle O'.
Now A, F, B, H are concyclic, their circle being O. Therefore their symmetrics with respect to C are concyclic; that is, B, K, A, L are concyclic,

and we will call their circle O''. The radical axes of circles O, O', O'', taken by pairs are concurrent. Circles O and O' intersect in DE; circles O' and O'' intersect in LK; circles O'' and O intersect in AB. Therefore DE, LK and AB are concurrent in a point I; obviously $CI' = CJ$. I', being the intersection of DE and AB must be the point, I, stated in the original problem. Therefore $CI = CJ$.

Solutions were also offered by Aaron Buchman, Buffalo, N. Y.; C. W. Trigg, Los Angeles City College.

1714. *Proposed by C. W. Trigg, Los Angeles City College.*

A sphere of radius, r, is rolled along a horizontal floor by a plank of thickness, a, until it comes into contact with a vertical wall. If the bottom of the plank is now at a distance, b, from the foot of the wall, find r. ($a \leqq r$, $r < b \leqq 2r$.)



Solution by Alan Wayne, New York, N. Y.

Taking a cross-section through the center of the sphere and its tangency points, we note in the figure that $AB = CF - DF = b - r$ and $OB = EF - AC = r - a$. Hence in triangle AOB, $r^2 = (b-r)^2 + (r-a)^2$ and solving, $r = a + b - \sqrt{2ab}$.

Solutions were also offered by Aaron Buchman, Buffalo, New York; and the proposer.

1715. *Proposed by Helen M. Scott, Baltimore, Maryland.*

A smooth cylinder, of 2-inch diameter, is in equilibrium, resting in a smooth hemispherical bowl, of 12-inch diameter. Half the bowl's volume of water is placed in it, which brings the water surface just in contact with the end of the cylinder. Find the length of the cylinder.

First Solution by Charles W. Trigg, Los Angeles College

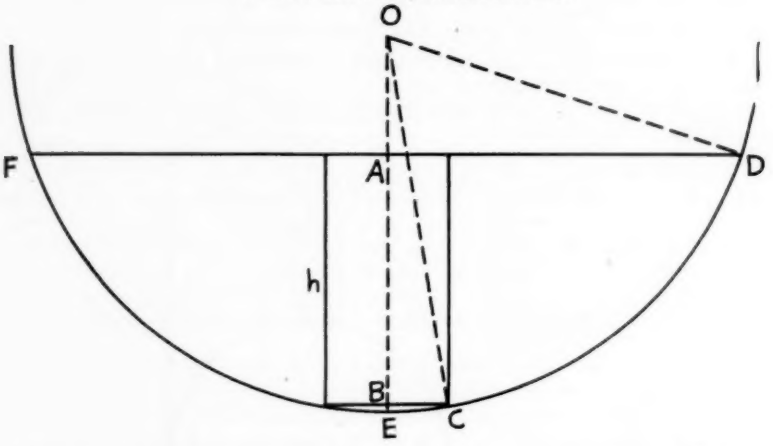
The figure shows a section through the bowl and cylinder. $OD = OC = OE = 6$, $BC = 1$, and $AB = h$. From the triangle OBC, $OB = \sqrt{35}$. Then $OA = (\sqrt{35} - h)$ and $AE = (6 - \sqrt{35} + h)$. From the triangle OAD, $AD^2 = 1 + 2h\sqrt{35} - h^2$.

If it be assumed that the water may run into the space below the cylinder, then half the volume of the bowl plus the volume of the cylinder equals the volume of the spherical segment *FADEF*. That is,

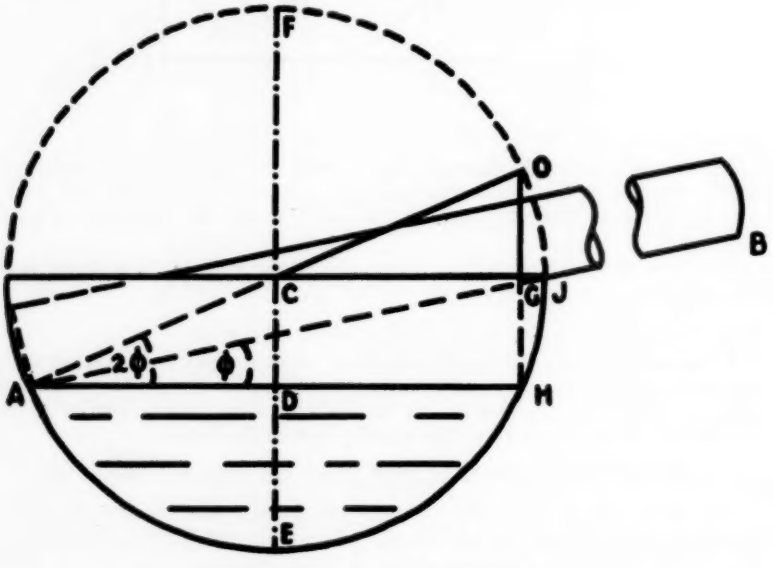
$$\tfrac{1}{3}\pi(6)^3+\pi(1)^2h=\tfrac{1}{2}\pi(6-\sqrt{35}+h)(1+2\sqrt{35}\,h-h^2)+\tfrac{1}{6}\pi(6-\sqrt{35}+h)^3.$$

$$h^3-3\sqrt{35}\,h^2+73\sqrt{35}-216=0.$$

$$h^3-17.7482394h^2+215.8738254=0.$$



This equation has one negative root, one root greater than $2\sqrt{35}$ and a third root which may be found by Horner's Method or otherwise to be 3.9563 inches, the length of the cylinder.



Second Solution by the Proposer

In the figure $AG=a$; $AB=2a$; $AO=12$; $DE=h$. The three forces AO, JO and GO keep the cylinder in equilibrium. Produce GO to meet the circle in H. Draw AG, which makes $\angle AHO=90°$, $\angle JAH=\angle KJA=\phi$. Therefore $\angle OAH=2\phi$

$$AH=2R\cos 2\phi=a\cos\phi. \tag{1}$$

Therefore

$$a=\frac{2R\cos 2\phi}{\cos\phi}.$$

Since the bowl is half filled with water, its volume is

$$\pi\frac{R^3}{3}.$$

The volume of the segment with altitude

$$DE=h \text{ is } \pi Rh^2-\frac{\pi h^3}{3}=\pi\frac{R^3}{3}.$$

When 6 is substituted for R this equation reduces to

$$h^3-18h^2+216=0 \text{ from which } h=3.9162=DE. \tag{2}$$

Then $DF=8.0838$. By simple geometry AD is easily found and by trigonometry

$$2\phi=20°\ 19'.$$

From (1) $a=11.4324$ and $AB=22.8648$.

Solutions were also offered by Walter M. Sackett, Jr., Evanston, Ill. and William A. Richards, Berwyn, Ill.

1716. *Proposed by Hugo Brandt, Chicago, Ill.*

In a rectangular coordinate system, whose axes are OX east, OZ south, OY upward, an irregular 3-sided pyramid with top T is given by its four faces. One of these is the base, $y=0$; another a vertical surface, $z=0$. The 2 remaining surfaces, $y=3x$, and $z=2(1-x)$, form the edge TS.

A wire is stretched from point $A(-4, 0, 0)$ across edge TS to point $B(6, 0, 0)$. Determine the point of (assumedly frictionless) contact between edge and wire.

Solution by the Proposer

If the point in question is $P(x, y, z)$, we have a minumim for $(AP+PB)$. Now

$$\overline{AP}^2=(4+x)^2+y^2+z^2$$
$$\overline{PB}^2=(6-x)^2+y^2+z^2.$$

By substituting

$$y^2=(3x)^2, \qquad z^2=4(1-x)^2$$

we find

$$\overline{AP}^2=14x^2+20 \quad \text{and} \quad \overline{PB}^2=14x^2+40-20x.$$
$$\therefore \quad \min=\sqrt{14x^2+20}+\sqrt{14x^2+40-20x}.$$

Differentiating:

$$0=\frac{14x}{\sqrt{14x^2+20}}+\frac{14x-10}{\sqrt{14x^2+40-20x}}$$

which reduces to: $63x^2+140x=50$.
From this $x=.313$.
Also $y=.939$ and $z=1.374$.

Solution was also offered by C. W. Trigg, Los Angeles City College.

STUDENT HONOR ROLL

The editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted to this department. Teachers are urged to report to the Editor such solutions.

PROBLEMS FOR SOLUTION

1729. *Proposed by P. D. Thomas, Norman, Okla.*

If in a triangle ABC, a^2, b^2 and c^2 are in arithmetic progression, show that tan A, tan B and tan C are in harmonic progression.

1730. *Proposed by Wilmer S. Wilson, Ovid, N. Y.*

Show that $(ab+cd)\ (ac+bd)>4\ abcd$, if each letter represents unequal positive numbers.

1731. If A and B are positive numbers greater than unity and $AB=C$, then

$$\log_{c^2} A+\log_{c^2} B+\log_{A^2} C+\log_{B^2} C\geqq\frac{17}{2}.$$

1732. *Proposed by Vernon Van Deventer, Los Angeles, Calif.*

Prove

$$(1-\sqrt{3})\sqrt{2+\sqrt{3}}=-\sqrt{2}.$$

1733. *Proposed by William W. Taylor, Woodrow Wilson Junior High School, Port Arthur, Texas.*

The line through the incenter of a triangle and perpendicular to the line joining the incenter with the circumcenter meets the incircle in two points. Show that the distance from the circumcenter to either of these two points is equal to the difference of the circumradius and inradius.

1734. *Proposed by Thomas A. Pickett, So. Weymouth, Mass.*

The walls of an ancient city were so constructed that the distances from any point on the wall to two isolated hills formed a constant ratio 7:5.

If one hill inside the walls is $2\frac{1}{2}$ miles from the center of the city, what is the shortest distance from the other hill to the wall? And what is the distance around the city by way of the walls?

SCIENCE QUESTIONS

October, 1941

Conducted by Franklin T. Jones,
10109 Wilbur Avenue, SE, Cleveland, Ohio

Contributions are desired from teachers, pupils, classes and general readers. Send examination papers from any source whatsoever, questions on any part of the field of science, tests, questions having to do with the pedagogy of science

—in fact, anything that appeals to the reader or might appeal to other readers; also, anything that will help to make the subjects arrayed under SCIENCE more useful or more interesting to teachers and pupils. Select your own topic. It will, most likely, be interesting to others.

We will endeavor to get answers to all reasonable questions. It is always valuable to get questions whether they can be answered or not.

Contributors to SCIENCE QUESTIONS are accepted into the GQRA (Guild of Question Raisers and Answerers).

Classes and teachers are invited to join with others in this co-operative venture in science.

INTEREST RAISERS IN ELEMENTARY SCIENCE

Beginning *in January 1941, each issue of SCIENCE QUESTIONS* has featured a set of questions and answers proposed and answered, mostly by pupils themselves, in ELEMENTARY SCIENCE.

Contributors have been—

Elementary Science Class at Doan School, Cleveland, Miss Anna E. Burgess, Then Principal Doan School, now Principal, Miles Standish School; Miss Mary Byrne and Miss Irene Van Chestein, Teachers, Doan School;

Elementary Science Class, Almira School, Cleveland, Miss Dorothy Bliesch, Teacher;

Science Class, 8A, and Boys' Science Class, 8th Grade, School No. 54, Mrs. Hellen Aufderheide, Teacher; and Bill Brendon, Pupil;

Miss Patricia Jean Porter, 7th Grade, Madison, Wis.;

Miss Mary Melrose, Supervisor of Elementary Science, Board of Education, Cleveland, Ohio;

Science Class, 6A, Warner School, Cleveland, Miss Clara Headapohl, Teacher;

Science Class, 6A. Rosedale School Cleveland, Miss Grace Curry, Teacher;

Individual students in the above classes, several elected to the GQRA;

Dr. David W. Russell, National College of Education, Evanston, Ill., and Editor for Bobbs-Merrill, Indianapolis, Ind., also a Departmental Editor of SCHOOL SCIENCE AND MATHEMATICS;

Mr. Virgil Stinebaugh, Assistant Superintendent, Board of Education, Indianapolis, Ind.

Others also have co-operated whose names, along with the most of the above, have appeared as members, old and new, of the GQRA (Guild of Question Raisers and Answers).

Thanks to all!!!

However, the more pupils and teachers who take part in this seeking of proper questions and answers that can be expected from pupils, the better Science Teaching will become.

Readers of SCHOOL SCIENCE AND MATHEMATICS please take notice and govern yourselves accordingly. Your contributions will always be gratefully received. (ED. JONES.)

Answers are particularly desired to the Interest Raisers published in June, 1941, from the classes of Mrs. Aufderheide and Miss Headapohl. Answers given prior to study of the subject are frequently as illuminating as answers given afterwards. (IR's No. 31 to 40, pages 593–594, June, 1931, SCHOOL SCIENCE AND MATHEMATICS).

SOME NEW INTEREST RAISERS

Proposed by 6th Grade pupils in Rosedale School, Cleveland, Ohio.

Below are some questions on various subjects that the children asked. Sixth Grade Class, Rosedale School, Cleveland, Miss Grace Curry, Teacher, Elected to the GQRA, No. 406.

---

41. *Proposed by Margaret Di Iorio.*
    If the earth is moving so fast around the sun, why doesn't it make us dizzy?
42. *Proposed by Dolores De More.*
    What causes earthquakes?
43. *Proposed by Arthur Egan.*
    What makes the earth rotate?
44. *Proposed by Mike Pasto.*
    How far does the force of gravity extend?
45. *Proposed by Anthony Ferguson.*
    What makes glass transparent when glass is made of materials that are not transparent?
46. *Proposed by Jane Dahl.*
    What makes thunder?
47. *Proposed by Rosalyn Jaffe.*
    Why do materials look one color in the sunlight and a different color in artificial light?
48. *Proposed by Mary Lou Corbin.*
    Why are there some grape fruits with seeds and some without?
49. *Proposed by Don Hulsebus.*
    How can you plant new trees from a tree with seedless oranges?
50. *Proposed by Don Roper.*
    Why do leaves fall from the trees in the fall?
51. *Proposed by Karl Holland.*
    How can they grow a cactus without spines?
52. *Proposed by Doris Stein.*
    Why do they say that plants with green leaves make their own food, when we learned when we were studying light that nothing has any color? We learned things just reflected part of the sun's rays.
53. *Proposed by Doris Kachman.*
    Why do some radios have an aerial and some do not?
54. *Proposed by George Castellano.*
    Why do planets always keep in the same path?

Answers to Interest Raisers proposed by Patricia Jean Porter (GQRA, No. 366), 7th Grade, Madison, Wis. by 6th Grade pupils in Rosedale School (GQRA, No. 406).

16. *Q.*—What is air made of?

    A.—*By Lucille Fitzpatrick.* Air is made of many different gases. The three most important are oxygen, carbon dioxide and nitrogen. Oxygen is the gas we breathe in and carbon dioxide is the gas we breathe out. Plants use the carbon dioxide when they make food. They also breathe in oxygen. Pure oxygen would be too strong for us so the nitrogen dilutes it.

17. *Q.*—If air has a pressure of 15 pounds per square inch, why aren't we crushed?

A.—*By Lois Merkle.* We breathe in oxygen from the air which has the same pressure as the air around us. If we have air in us and air around us which has the same pressure, we will not be crushed.

18. *Q.*—Why is the moon sometimes round and sometime crescent-shaped?

A.—*By Lois Merkle.* One-half of the moon is always lighted. The moon goes around the earth and we can't always see all the lighted part. When the moon is between us and the sun, the dark side is toward us and we call it "new moon" because we can't see any of the lighted part. When it gets on the opposite side of the earth, we can see the whole circle. When it travels from new moon to full moon we see a crescent first and each night the crescent seems to get a little larger until we see half the circle. It keeps getting larger until we see all the circle and then it begins to get smaller again.

19. *Q.*—Where do the insects stay during the winter?

A.—*By Virginia Ventresca.* Most insects die in the winter. Many spend the winter in a cocoon and come out as an adult in the spring. Some hibernate in cracks in the house or in decayed wood or in piles of leaves. In the spring they come out and begin laying eggs.

20. *Q.*—Why do most birds fly south in the winter?

A.—*By Richard Baumgartner.* No one seems to know exactly why birds fly south in the winter. Some think it is for food and some think it is to get away from the cold; but some birds stay in the north and the cold does not seem to hurt them. Scientists are still studying this problem.

21. *Q.*—Why can't you run away from the moon in an automobile?

A.—*By Dorothy Brier.* You cannot run away from the moon because it is thousands of miles away from us. If you were riding in an automobile and passed a street light, it would soon be out of sight because it is so near us. The moon is such a great distance away from us that the short distances on the earth can't take us far enough to be out of sight of it.

22. *Q.*—What keeps the earth and the other planets in their places?

A.—*By Mike Pasto.* Gravitation keeps the planets in their places. It is a great force. Every object in the universe pulls on every other object.

23. *Q.*—Why does an object in a mirror seem to be behind the mirror?

24. *Q.*—Why do you see your right hand as your left in a mirror?

Answers to 23 and 24 seemed to be too difficult for the children.

25. *Q.*—Where does water go when it evaporates?

A.—*By Rosalyn Jaffe.* Water goes into the air when it evaporates. It is called water vapor which is a colorless gas and we cannot see it. When it is cooled, it condenses and turns back to water again.

WHO ELSE HAS A LIST OF QUESTIONS THAT PUZZLES HIM?

ANSWERS WANTED

924. *Ten Questions from a Class of Eighth Grade Boys.* (SCHOOL SCIENCE AND MATHEMATICS, May, 1941, Page 497.)
929. "Flowers in the Sick Room." *Question by W. Ming Foo.* (SCHOOL SCIENCE AND MATHEMATICS, June, 1941, Page 595.)
927. "Weight of the Ham." (Same, pp. 594–595.)

KEEPING UP WITH INDUSTRY

919. How to keep up with science and industry?

An Answer—

Get yourself on the mailing list of the great industrial organizations which are asisting in the advance of science and the improvement of industry. You will be surprised to find that these concerns give information with a minimum of so-called propaganda. They tell the truth.

For example, here is a

STEEL QUIZ—

930. Taken from "Steel Facts," published by American Iron and Steel Institute, 350 Fifth Avenue, New York. (Yours for the asking.) *Six correct answers on this quiz is a good average. Answers given below.*

1. Of the total tonnage of raw materials which they need, steel companies themselves mine or produce: (a) 25%; (b) 50%; (c) 75%.
2. Kish is: (a) a powder-like graphite that separates from molten iron when cooling; (b) waste pickle liquor that has been used to clean sheet steel; (c) the hardened mass of slag and iron which solidifies in the bottom of a blast furnace.
3. The first recorded production of nickel alloy steel in the United States was in: (a) 1865; (b) 1890; (c) 1917.
4. In steel mill parlance, a church steeple is: (a) a tall chimney stack of an open hearth furnace; (b) a transverse crack in a finished steel product; (c) the control room from which a continuous sheet mill is operated.
5. As compared with 1929, steel wages are now: (a) ten per cent higher; (b) about the same; (c) 50% higher.
6. Steel containing about 12% manganese, when given hard use in service becomes: (a) harder and tougher; (b) softer; (c) brittle and shiny.
7. The critical temperature is a term applied to the temperature at which steel: (a) melts; (b) develops a different molecular structure; (c) becomes red hot.
8. The first successful use of coal in a blast furnace occurred in: (a) 1556; (b) 1735; (c) 1855.
9. The melting point of ordinary steel is: (a) 2700°F.; (b) 3300°F.; (c) 4000°F.
10. Of total steel exports from the United States last year, the percentage going to the United Kingdom was: (a) 5%; (b) 25%; (c) 45%.

Answers to Steel Quiz:

1. 75%. 2. (a). 3. (b) an alloy containing 3½% nickel was first produced in Pittsburgh in 1890. 4. (b) A church steeple is a defect consisting of a transverse crack in rolled steel. 5. (c) Steel wage increases effected in April, 1941, brought average wages to about 97 cents per hour, compared with 65 cents in 1929, an increase of almost 50%. 7. (b) When steel is heated, its molecular structure changes at several critical temperatures, beginning at

about 1300°F. 8. (b) In 1735, for the first time, Abraham Darby in Shropshire, England, successfully used coke as fuel in a blast furnace. Before that charcoal was used exclusively in manufacturing iron. 9. (a) The melting of low carbon steel is about 2700°F. 10. (c) The United Kingdom took 3,906,000 net tons of steel from the United States last year, or about 45% of total steel exports in 1940.

TELL THE EDITOR WHERE OTHER SIMILAR LISTS OF QUESTIONS CAN BE OBTAINED

AN ANSWER TO AN INTEREST RAISER

By Marjorie Rose Bleiler, Mercy High School, Milwaukee, Wis. (Elected to the GQRA, No. 407.)

Interest Raiser No. 12.

Q.—Why do you see the lightning before you hear the thunder?

A.—"The heat produced by the electric discharge traversing the atmosphere causes the sudden expansion of the particles next to it, with a sharp compression of those beyond, causing thunder by the wave motion thus initiated." (This is a sound wave and travels say 1100 feet per second. The electric discharge sets up a light wave which travels 186,000 miles per second. The light wave reaches you before the sound wave.)

The quoted part of this answer is also an answer to I.R. No. 46 in this issue. "What makes thunder?"

DO YOU KNOW THE ANSWERS?

Suggested to the Editor on looking at the new National Geographic Map of the Atlantic Ocean. (Answers follow.)

141. Are the Canary Islands named after birds?
142. In what direction does the Panama Canal run?
143. Why is the language of Brazil Portuguese?
144. What great ocean currents enter the Gulf of Mexico? What current leaves?
145. What is the "deep spot" in the Atlantic Ocean?

Look at the map and find the onswers.

141. No, they are named after "dogs"—"Called *Canaria* from multitude of dogs of great size."
142. NW to SE. Colon on the Atlantic end of the Panama Canal is NW of Panama on the Pacific end.
143. 50° West Longitude of demarcation line of the Treaty of Tordesillas, 1494. Today, because of this treaty, the language of Brazil is Portuguese. Brazil from Estuario do Rio Amazono to near Porto Alegre, about 30°S. Lat. is *east* of Long 50°W.
144. Entering—South Equatorial and North Equatorial Currents: Leaving—Gulf Stream.
145. Nares Deep—22,949 feet. In the Sargasso Sea about Long. 60°W.; Lat. 28°N.

PRODUCTS AND BY-PRODUCTS OF PHYSICS

922. (*April, 1941*). *"What are five of the most valuable facts or by-products that I, as a teacher, believe my pupils got out of my physics class this year?"*

Answer by Nathan A. Neal, James Ford Rhodes High School (GQRA, No. 365), Arthur O. Baker, Same (GQRA, No. 364), and F. R. Bemisderfer, West Technical HS (GQRA, No. 6).

"Some weeks ago I was asked to co-operate with F. R. Bemisderfer and A. O. Baker in writing a statement on what we believed to be the important facts and by-products of Physics in terms of Asst. Supt. Bryan's listing of *seven* major objectives for high school education. These constitute my rather full answer to 922."
(Mr. Neal's statement follows.)

The Science Program

Science contributes definitely and heavily to such recognized objectives of education as *health; the American way of life; consumer education; fundamental processes; occupations; personal regimen;* and *leisure.* Our entire socio-economic scheme of living is based upon man's ability to understand and harness the scientific phenomena of his environment. By directing the program in science education towards sound educational objectives, the avenues to better living are opened. Thus man learns how to work with tools and machines; how to construct, equip, and operate desirable homes; how to grow plants for food and fabrics; how to protect himself against such enemies as bacterial parasites and insect pests; and how to think critically and scientifically about the things he buys.

The contribution which Physics makes to these objectives may be stated as follows:

Topics in Physics Which Contribute to the Realization of Educational Objectives

1. *Health*

1. The relation of air pressure to certain pulmonary diseases.
2. The importance of ventilation to health.
3. The relation of humidity to physical welfare.
4. The importance of different kinds of thermometers to health.
5. Use of the hygrometer in determining humidity.
6. The heat of fusion principle used in refrigeration.
7. The use of the heat of vaporization principle in mechanical refrigeration.
8. The relation of specific heat to climate.
9. The importance of conduction, convection, and radiation in home heating and air conditioning.
10. The use of electricity in medicine.
11. The importance of proper home and industrial lighting.
12. The relation of city and industrial noises to health.
13. Sound, hearing, hearing aids, and health.
14. Structure and care of the eye.
15. Types of lenses used to correct eye defects.
16. The aspirator in relation to health.
17. The importance of different kinds of microscopes in health studies.
18. The relation of water purification and sewage disposal to health.

2. *The American Way of Life*

1. How principles of transportation affect our way of life.
2. The automobile as a factor in modern living.
3. The airplane as a factor in modern living.
4. Distribution of the benefits of water power.

3. *Consumer Education*

1. The principles of hydraulics as applied to purchasing hydraulic appliances.
2. Specific units of measurement that have household applications.
3. The principles of work, power and energy, mechanical efficiency, and their relation to evaluating advertising of mechanical devices.
4. The principles of refrigeration.
5. Different types of heating systems for the home.
6. Calorie and B.T.U. as important factors in evaluating and buying fuels.
7. The laws and properties of magnets and their relation to repairing slightly damaged motors, door bells, and other electro-magnetic appliances.
8. The limitations of electricity in medicine.
9. The principles of dry cells, storage batteries and various electrical units that increase efficiency in certain machines used in the home.
10. The principles of electrolysis and electrolytic processes as applied to plated dinnerware, kitchen utensils, and jewelry.
11. The terms volt, ampere, watt, watt hour, and kilowatt hour, and their use in predetermining cost of operation of any proposed electrical appliance.
12. The terms transparent, translucent, opaque, candle power, foot-candle, sight-meter, photo-electric cell, photometer, and fluorescense and their use in purchasing proper modern lighting equipment.
13. Lens principles which may be important in purchasing eye glasses, cameras, mirrors, and optical instruments.
14. Principles in simple machines, lever, pulley, siren, wheel and axle, wedge and inclined plane which may be of great value in purchasing and repairing various types of household equipment.
15. Use of tensile strength, horse-power, watt, potential energy, kinetic energy and friction in evaluating advertising of mechanical products.

4. *Fundamental Processes*

1. Weights, measures, and units of force which are fundamental to modern living.
2. The terms of mass, time, space, and matter and their relation to various problems of living.
3. Certain properties of matter such as liquid, solid, gas, crystalline, amorphous, viscous, malleable, and ductile states which are fundamental to various aspects of modern living.
4. The relation of certain metric units to English units.
5. The principles of household and automobile meters.
6. The relation of expansion and construction to various types of safety appliances.
7. Problem reading and solving which may contribute to fundamental processes in everyday living.

5. *Occupations*

1. Probably every principle and law studied in Physics is the basis of some great industry which employs large numbers of people. Hence

for a limited number of individuals each principle and law studied may contribute to occupational perspective. Example of some principles and laws which come within this classification are: hydrostatics, hydraulics, hydrometry, hygrometry, barometry, thermometry, gas laws, motion, velocity, acceleration, centrifugal force, power, laws of mechanics, thermostatic principles, principle of heat engines, magnetic laws, principles of electricity including electrolytic processes, electric heat and power, and the principles of the telephone, telegraph, radio, electric motor, electric generator, electric bells, and television.

6. *Personal Regimen* (*Social Living*)

1. The modern devices of communication, transportation and power distribution, present problems in the science class-room which are closely related to social living.

7. *Leisure*

1. The laws and principles of magnets and electricity may contribute to the development of hobbies of an almost infinite variety.
2. The physical principles of speech, hearing, sound and music may contribute to wider distribution of pleasurable activities in these areas.
3. The elementary principles of lenses which are necessary in carrying out satisfactory amateur photography.

GQRA—NEW MEMBERS, OCTOBER, 1941

406. Sixth Grade Science Class, Rosedale School, Cleveland, Ohio, Miss Grace Curry, Teacher, and Pupils who participated by named contributions:—Lucille Fitzpatrick, Lois Merkle, Virginia Ventresca, Richard Baumgartner, Dorothy Brier, Mike Pasto, Rosalyn Jaffe, Margaret Di Iorio, Dolores De More, Arthur Egan, Anthony Ferguson, Jane Dahl, Mary Lou Corbin, Don Hulsebus, Don Roper, Karl Holland, Doris Stein, Doris Kachman, George Castellano.

407. Marjorie Rose Bleiler, Mercy HS., Milwaukee, Wis.

Contribute !!! **JOIN THE GQRA**

BOOKS AND PAMPHLETS RECEIVED

ANIMAL BIOLOGY, by Michael F. Guyer, *Professor of Zoology, University of Wisconsin*. Third Edition. Cloth. Pages xix+723. 15×23.5 cm. 1941. Harper and Brothers, 49 East 33rd Street, New York, N.Y. Price $3.75.

ELEMENTS OF THE DIFFERENTIAL AND INTEGRAL CALCULUS, by William Anthony Granville, *formerly President of Gettysburg College*, and Percey F. Smith and William Raymond Longley, *Professors of Mathematics, Yale University*. Revised Edition. Cloth. Pages xi+556. 15×23.5 cm. 1941. Ginn and Company, Statler Office Building, Park Square, Boston, Mass. Price $3.60.

ELEMENTARY CALCULUS, by Volney H. Wells, *Associate Professor of Mathematics in Williams College*. Cloth. Pages xiii+410. 15×23 cm. 1941. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York, N.Y. Price $3.25.

HOW MIRACLES ABOUND, by Bertha Stevens, Author of *Child and Universe*, and *Thoreau: Reporter of the Universe*. Cloth. 200 pages. 15×21 cm. 1941. The John Day Company, Inc., 2 West 45th Street, New York, N. Y. Price $2.50.

COLLEGE PHYSICS, by Henry A. Perkins, *Professor of Physics, Trinity College*. Abridged. Cloth. Pages ix+591. 15×23 cm. 1941. Prentice-Hall, Inc., 70 Fifth Avenue, New York, N. Y. Price $3.50.

BUSINESS ARITHMETIC, A REVISION OF THE ORIGINAL THOMPSON'S BUSINESS ARITHMETIC, by Henry Smithline, *Instructor in Business Mathematics, New Utrecht High School and School of Commerce, St. John's University, New York City*, and Clyde O. Thompson, *Late Associate Principal, Mount Vernon, New York High School and Supervisor of Commercial Education, Mount Vernon, New York*. Cloth. Pages xi+496. 15×23 cm. 1941. Prentice-Hall, Inc., 70 Fifth Avenue, New York, N. Y. Price $1.60.

SCIENCE OF LIVING THINGS, by Clinton G. Weymouth, *Greenfield High School, Greenfield, Massachusetts*. Cloth. Pages viii+534. 14.5×23.5 cm. 1941. Henry Holt and Company, Inc., 257 Fourth Avenue, New York, N. Y. Price $1.84.

FUNDAMENTAL OF MATHEMATICS, by M. Richardson, *Instructor in Mathematics, Brooklyn College*. Cloth. Pages xviii+525. 1941. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $3.25.

SIMPLE CHEMICAL EXPERIMENTS, by Alfred Morgan. Cloth. Pages v+269. 13×19.5 cm. 1941. D. Appleton-Century Company, 35 West 32nd Street, New York, N. Y. Price $2.00.

SENIOR PRACTICAL MATHEMATICS, by N. J. Lennes. Cloth. Pages xiii +584. 13×20 cm. 1941. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $1.80.

BRIEF TRIGONOMETRY, by Edward A. Cameron, *University of North Carolina*. Cloth. Pages viii+121+17. 13.5×21.5 cm. 1941. Reynal and Hitchcock, Inc., 386 Fourth Avenue, New York, N. Y. Price $1.25.

LIFE SCIENCE, by Ralph C. Benedict, *Professor of Biology in Brooklyn College;* Warren W. Knox, *Director, Division of Secondary Education in the New York State Department of Education;* and George K. Stone, *Supervisor of Secondary Education in the New York State Department of Education*. Cloth. Pages xiv+682. 13.5×21.5 cm. 1941. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $2.00.

ELEMENTARY FUNCTIONS AND APPLICATIONS, by Arthur Sullivan Gale, and Charles William Watkeys, *Professors of Mathematics in the University of Rochester*. Revised. Cloth. Pages xxi×409. 13.5+21.5 cm. 1941. Henry Holt and Company, 257 Fourth Avenue, New York, N. Y. Price $2.25.

MATHEMATICS FOR ELECTRICIANS, by Martin H. Kuehn, *Instructor of Mathematics, Seneca Vocational High School, Buffalo, New York*. Second Edition. Cloth. Pages xi+254. 13.5×20.5 cm. 1941. McGraw-Hill Book Company, 330 West 42nd Street, New York, N. Y. Price $1.75.

GIOVANNI MARLIANI AND LATE MEDIEVAL PHYSICS, by Marshall Clagett. Cloth. 182 pages. 14.5×22.5 cm. 1941. Columbia University Press, New York, N. Y. Price $2.50.

GENERAL BIOLOGY, by James Watt Mavor, *Professor of Biology in Union College*. Revised Edition. Cloth. Pages xxx+897. 15.5×23.5 cm. 1941. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $4.00.

PRACTICAL MATHEMATICS, PART IV—TRIGONOMETRY AND LOGARITHMS, by Claude Irwin Palmer, *Late Dean of Students and Professor of Mathematics, Armour Institute of Technology*, and Samuel Fletcher Bibb, *Associate Professor of Mathematics, Illinois Institute of Technology, Armour College of Engineering*. Cloth. Pages xii+209. 11.5×17.5 cm. 1941. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N. Y. Price $1.25.

CURRENT PRACTICES IN INSTITUTIONAL TEACHER PLACEMENT, written by Thirty-five Members of the National Institutional Teacher Placement Association. Editorial Committee: Earl W. Anderson, *Ohio State University;* John Douglas Leith, *Teachers College, Columbia University;* and Ralph F. Strebel, *Chairman, Syracuse University*. Cloth. Pages xi+186. 15×23 cm. 1941. National Institutional Teacher Placement Association, University of Georgia, Athens, Georgia.

FIRST YEAR OF COLLEGE MATHEMATICS, by Henry J. Miles, *Associate in Mathematics, University of Illinois*. Cloth. Pages xvii+607. 13.5×21.5 cm. 1941. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price $3.00.

COLLEGE PHYSICS, by Arthur L. Foley, *Emeritus Professor of Physics, Indiana University*. Third Edition. Cloth. Pages xvi+756. 14.5×21.5 cm. 1941. The Blakiston Company, 1012 Walnut Street, Philadelphia, Pa. Price $3.75.

THE FLOWER FAMILY ALBUM, by Helen Field Fischer, *Radio Garden Consultant*, and Gretchen Fischer Harshbarger, *Landscape Architect and Horticultural Illustrator*. Cloth. 130 pages. 21.5×27.5 cm. 1941. University of Minnesota Press, 100 Wesbrook Hall, Minneapolis, Minn. Price $2.50.

ESSENTIALS OF SHOP MATHEMATICS, by Samuel Slade, *Administrative Assistant, New York Vocational High School*, and Louis Margolis, *Brooklyn High School for Metal Trades, City of New York*. Cloth. Pages viii+194. 13×19.5 cm. 1941. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price $1.50.

COLLEGE GEOMETRY, by Paul H. Daus, *Associate Professor of Mathematics, University of California, Los Angeles*, Cloth. Pages xv+200. 14.5 ×23 cm. 1941. Prentice-Hall, Inc., 70 Fifth Avenue, New York, N. Y. Price $2.50.

MATHEMATICAL TABLES, by Herbert Bristol Dwight, *Professor of Electrical Machinery, Massachusetts Institute of Technology*. Cloth. Pages vii+ 231. 15×23 cm. 1941. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York, N. Y. Price $2.50.

PLANE FACTS FOR AIRPLANE AND ENGINE MECHANICS, by Bert A. Kutakoff. Cloth. 251 pages. 13×19 cm. 1941. Military Book Company, 621 Broadway, New York, N. Y. Price $1.75.

A STUDY-BOOK FOR SCIENCE PROBLEMS 3, by Wilbur L. Beauchamp, John C. Mayfield and Joe Young West. Paper. Pages iv+316. 19.5×26.5

cm. 1941. Scott, Foresman and Company, 623 S. Wabash Avenue, Chicago, Ill. Price 76 cents.

INTRODUCTION TO AVIATION, by James P. Eames, *Consulting Aeronautical and Mechanical Engineer*. Cloth. Pages ix+196. 13.5×21.5 cm. 1941. The Chemical Publishing Company, Inc., 234 King Street, Brooklyn, N. Y. Price $3.50.

ENGINEERING DRAWING, by D. E. Hobart, *Assistant Professor of Mechanism and Engineering Drawing, University of Michigan*. Cloth. Pages vii+430. 15×23.5 cm. 1941. D. C. Heath and Company, 285 Columbus Avenue, Boston, Mass. Price $2.75.

MECHANICS, by John W. Breneman, *Associate Professor of Engineering Mechanics*. Prepared under the Direction of the Division of Engineering Extension, The Pennsylvania State College. Cloth. Pages x+141. 15×23 cm. 1941. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York, N. Y. Price $1.50.

MATHEMATICS, by John W. Breneman, *Associate Professor of Engineering Mechanics*. Prepared under the Direction of the Division of Engineering Extension, The Pennsylvania State College. Cloth. Pages xii+210. 15×23 cm. 1941. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York, N. Y. Price $1.75.

STRENGTH OF MATERIALS, by John W. Breneman, *Associate Professor of Engineering Mechanics*. Prepared under the Direction of the Division of Engineering Extension, The Pennsylvania State College. Cloth. Pages x+145. 15×23 cm. 1941. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York, N. Y. Price $1.50.

THIS PHYSICAL WORLD, by C. C. Clark, *Associate Professor of General Science, New York University;* C. A. Johnson, *Instructor in General Science, New York University;* and L. M. Cockaday, *Lieut. Comdr., U. S. N., Military Instructor in Physics, United States Naval Academy*. Cloth. Pages x+528. 15×23 cm. 1941. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York, N. Y. Price $3.25.

THE ELEMENTS OF STATISTICS, by Elmer B. Mode, *Professor of Mathematics, Boston University*. Cloth. Pages xvi+378. 15×23 cm. 1941. Prentice-Hall, Inc., 70 Fifth Avenue, New York, N. Y. Price $3.50.

MUSICAL ACOUSTICS, by Charles A. Culver, *Professor of Physics, Carleton College*. Cloth. Pages xiii+194. 14.5×21.5 cm. 1941. The Blakiston Company, 1012 Walnut Street, Philadelphia, Pa. Price $2.50.

THE MARCH OF MEDICINE. New York Academy of Medicine Lectures to the Laity, 1940. Cloth. Pages xii+154. 13×20.5 cm. 1941. Columbia University Press, Morningside Heights, New York, N. Y. Price $2.00.

FUNDAMENTALS OF PHYSICAL SCIENCE, by Konrad Bates Krauskopf, *Assistant Professor of Geology, Stanford University*. Cloth. Pages x+660. 15×23 cm. 1941. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York, N. Y. Price $3.50.

BUTTERFLIES, by Ralph W. Macy, *Professor of Biology, College of St. Thomas*, and Harold H. Shepard, *Assistant Professor of Entomology, University of Minnesota*. Cloth. Pages vii+247. 15×23 cm. 1941. University of Minnesota Press, Minneapolis, Minn. Price $3.50.

LABORATORY MANUAL FOR GENERAL CHEMISTRY, by Albert L. Elder, *Professor of Chemistry, Syracuse University*. Paper. Pages x+259. 17.5×25.5 cm. 1941. Harper and Brothers, 49 East 33rd Street, New York, N. Y. Price $2.00.

BIOLOGY AND HUMAN AFFAIRS, by John W. Ritchie. Cloth. Pages xiv+1026. 15×22.5 cm. 1941. World Book Company, Yonkers-on-Hudson, N. Y. Price $2.32.

PRINCIPLES OF GENERAL CHEMISTRY, by Stuart R. Brinkley, *Associate Professor of Chemistry, Yale University*. Third Edition. Cloth. Pages x+703. 15×23.5 cm. 1941. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $4.00.

COLLEGE ALGEBRA, by H. P. Pettit, *Professor and Head of Department of Mathematics, Marquette University*, and P. Luteyn, *Assistant Professor of Mathematics, Marquette University*. Second Edition. Cloth. Pages xiv+247. 14×21.5 cm. 1941. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price $1.90.

GENETICS AND THE ORIGIN OF SPECIES, by Theodosius Dobzhansky, *Professor of Zoology in Columbia University*. Second Edition, Revised. Cloth. Pages xviii+446. 14.5×22.5 cm. 1941. Columbia University Press, Morningside Heights, New York, N. Y. Price $4.25.

LABORATORY GUIDE IN ELEMENTARY BACTERIOLOGY, by M. S. Marshall, *University of California, San Francisco*. Cloth. Pages xii+244. 14.5×23 cm. 1941. The Blakiston Company, 1012 Walnut Street, Philadelphia, Pa. Price $1.75.

THE SECOND YEARBOOK OF RESEARCH AND STATISTICAL METHODOLOGY, Edited by Oscar Krisen Buros. Cloth. Pages xx+383. 18.5×26.5 cm. 1941. The Gryphon Press, 32 Lincoln Avenue, Highland Park, N. J. Price $5.00 less ten per cent on orders sent direct.

TEST IT YOURSELF, by Lawrence F. Tuleen, Willard L. Muehl, and George S. Porter, *Instructors of Chemistry, J. Sterling Morton High School and Junior College, Cicero, Illinois*. Paper. Pages vi+290. 19.5×26.5 cm. 1941. Scott, Foresman and Company, 623 S. Wabash Avenue, Chicago, Ill. Price for High School and Junior College, 96 cents, and Teacher's Edition, $1.08.

GENERAL EDUCATION BOARD ANNUAL REPORT FOR 1940. Founded by John D. Rockefeller in 1902. Paper. 216 pages. 14.5×22 cm. General Education Board, 49 West 49th Street, New York, N. Y.

WORKBOOK IN PSYCHOLOGY, by John J. B. Morgan, *Professor of Psychology, Northwestern University*. Paper. Pages iv+122. 16×24 cm. 1941. Farrar and Rinehart, Inc., 601 West 26th Street, New York, N. Y. Price 80 cents.

INDUSTRIAL MATHEMATICS, by Thornton C. Fry, *Mathematical Research Director, Bell Telephone Laboratories*. Paper. 38 pages. 15.5×23 cm. June 1941. Bell Telephone Laboratories, Inc., 463 West Street, New York, N. Y.

STATE SUPERVISORY PROGRAMS FOR THE EDUCATION OF EXCEPTIONAL CHILDREN, by Elise H. Martens, *Senior Specialist in the Education of Exceptional Children*. Monograph No. 10. Paper. Pages x+92. 14×23.5 cm. 1941. Superintendent of Documents, Washington, D. C. Price 25 cents

OUTLINE OF THE HISTORY OF MATHEMATICS, by Raymond Clare Archibald, *Professor of Mathematics, Brown University*. Fifth Edition Revised, and Enlarged. Paper. Pages 11+76. 15×23 cm. 1941. The Mathematical Association of America, Inc., Oberlin, Ohio. Price 75 cents a copy, postpaid, remittance with order.

THE ROCKEFELLER FOUNDATION, A REVIEW FOR 1940, by Raymond B. Fosdick, *President of the Foundation*. Paper. 64 pages. 15×23 cm. 1941. New York, N. Y.

RCA ELECTRON MICROSCOPE. Paper. 23 pages. 22×29.5 cm. 1941. RCA Manufacturing Co., Camden, N. J.

SPENCER POLARIZING MICROSCOPES. Paper. 25 pages. 18×25.5 cm. Spencer Lens Company, Buffalo, N. Y. Catalog may be had upon request.

BOOK REVIEWS

COLLEGE PHYSICS, by Arthur L. Foley, *Emeritus Professor of Physics, Indiana University*. Cloth. Pages xvi+757. 14×21 cm. 1941. The Blakiston Company, Philadelphia, Pa. Price $3.75.

This is the third edition of a well-known text in college physics, the second edition of which appeared in 1937. Like the earlier editions this revision is written for the general student and attempts to make the work interesting as well as informative. This edition follows closely the second edition although there has been some revision of subject matter. The number of chapters has been decreased and elasticity has been emphasized by making it a separate chapter. The book has been decreased in length by some twenty-four pages; at the same time it includes more pictures and figures. This decrease comes chiefly in mechanics, particularly in those chapters dealing with forces and motions. Some minor topics have been omitted and some discussions considerably abbreviated. A few new topics e.g. weather and climate, have been added. Those sections other than mechanics are of approximately the same length as in the second edition although many topics have been rewritten. The text questions and general questions at the end of each chapter are the same, but the problems are new or have been rewritten making the old answers incorrect. An index of the data tables which are scattered throughout the text should be very useful.

R. R. HANCOX
Wilson Junior College
Chicago, Ill.

GIOVANNI MARLIANI AND LATE MEDIEVAL PHYSICS, by Marshall Clagett, *Professor of Political Science in Columbia University*. Cloth. Pages 182. 14.5×22 cm. 1941. Columbia University Press, New York, N. Y. Price $2.50.

This book gives a summary of physical thought in the fourteenth and fifteenth centuries, with particular emphasis on the contributions of Giovanni Marliani. It gives first a biographical sketch of Marliani and a short description of all his known manuscripts and works. His works divide themselves into three classes: (1) heat, which treats various cases of reaction between hot and cold bodies; (2) motion, which discusses uniformly accelerated motion and the dependence of velocity on the ratio of the motive force to the resistance; and (3) a discussion of vulgar fractions.

Marliani is not represented as being the outstanding scientist of his period, but as a vigorous and active physicist who exercised considerable influence on the thinking of the time. The book is an interesting contribution to the history of science and should find a place in many libraries.

R. R. HANCOX

TEXTBOOK OF CHEMISTRY, by Albert L. Elder, *Professor of Chemistry, Syracuse University.* Cloth. Pages viii+751. 15×23.5 cm. 1941. Harper and Brothers, 49 East 33rd Street, New York, N. Y. Price $3.75.

This text is designed for a beginning course for students with scientific aptitude who plan to make some branch of science their life work. Somewhat more than the usual material in an elementary text is presented in order to answer the questions from the type of student for whom the book was written. The approach to the subject is made through the use of up to date physical chemistry. For the first one hundred and forty pages, the theories relating to the understanding of the structure of matter are discussed as completely as possible for an elementary book. After that, the reader is introduced to the chapter on hydrogen and the more factual material usually included in the early chapters. Sufficient emphasis upon modern theory and the clear explanation of its significance will enable the student entering advanced courses to make the transition easily.

There are a number of features in this text which are worth noting. The style is concise. Many questions are naturally included in the body of the text to arouse the student's curisoity. Excellent and well chosen commercial photographs have been collected. The author has utilized historical notes to a large extent to enhance the interest in the logical development of chemistry. There are an unusual number of delightful and original comparisons between difficult chemical concepts and the everyday experiences of the reader. A large proportion of the questions at the end of the chapters are mathematical problems which give a much needed stress on this side of the science. Special care has been taken to explain the method for solving each type of problem which at this stage the chemists must know how to handle. An excellent summary of these types is included. The lists of reference books and articles appear to be extremely well chosen from recent standard works and contemporary chemical journals. The diagrams are clear cut; new charts are instructive; and good judgment has included devices that direct the reasoning power of the individual. Effort has been made to associate theoretical with factual material which insures the best foundation for future study. This text is too serious a volume for a general course given to any beginning college student. It serves its purpose as a sound accurate text for the would be scientist or chemist.

VIRGINIA BARTOW
Douglas, Michigan

THE EARTH AND ITS RESOURCES, by Vernor C. Finch. *Professor of Geography, University of Wisconsin;* Glenn T. Trewartha, *Professor of Geography, University of Wisconsin;* and M. H. Shearer, *Westport High School, Kansas City, Missouri.* Cloth. Pages v+634. 15×23 cm. 1941. McGraw-Hill Book Company, 330 West 42nd Street, New York, N. Y. Price $2.40.

This is an excellent high school text in physical geography and perhaps the best that has yet been written. The factual material has been drawn from the most accurate and recent sources available and is illustrated with over four hundred maps, diagrams, and well-chosen photographs. The content and organization are patterned after *Elements of Geography,* a

college text by the two senior authors, but the clear, simple presentation is at a level that will be understandable to the beginning student of the subject.

It is the purpose of the book to present "the basic facts concerning the earth as the home of man so that the student may realize their importance and understand their relationship to the problems of his own time and place." Its content can be divided into four major, unequal parts: (1) weather and climate, topics of special interest to young aviation enthusiasts; (2) landforms—plains, plateaus, hill country, and mountains; (3) the oceans and their shores; and (4) earth resources. The latter section touches upon the current problem concerning conservation of the major exhaustible resources.

This text differs from most other high school texts on the subject in two ways. It places a greater emphasis on meteorology and climate and it considers the elements of the natural landscape in their regional combinations and in the light of their value for man's social and economic use. A concluding chapter on the major physical regions and resources of the United States gives an interesting application of the facts presented.

A laboratory manual has been written to accompany this text so that the material may be used in the manner of other laboratory sciences. This, together with the material included in the appendices, will allow the book to be used for either a semester or a full-year course.

ALDEN CUTSHALL
University of Illinois

ORGANIC CHEMISTRY, by Nicholas D. Cheronis, *Chicago City Colleges*. Cloth. Pages v+728. 15×23 cm. 1941. Thomas Y. Crowell Company, 432 Fourth Avenue, New York, N. Y. Price $4.00.

This book is a welcome addition to the list of good elementary organic textbooks available. The author's method of approach to the subject is somewhat different than most, and it has many points in its favor. The first fifty pages serve both as an introduction to organic chemistry and as a review of those topics of inorganic chemistry—compound formation, electrovalence, covalence, the coordinate bond, ionization, etc.—the mastery of which is so necessary to the beginning organic student. This essential background material is well and thoughtfully presented. The next seventy-odd pages deal with the hydrocarbons; although this may seem an excessive amount of space to devote to that subject, the author states that his teaching experience has shown that the present extended development results in an earlier and better grasp of the whole subject by the student. This may well be, for the presentation is a logical one (though a bit wordy at times), and the idea of introducing benzene along with the aliphatics works out very well, a unified picture of the hydrocarbon family resulting. Throughout the book, the simpler aromatic compounds have been introduced along with the aliphatic ones for comparative purposes.

Each homologous series is introduced by giving the general methods of preparation, reactions, properties, and uses of the series, followed by individual discussion of the more important members of the series. There are numerous tables of data of physical properties presented, and many charts are included giving summaries of reactions, relationships between various homologous series, and other useful information.

The chapters on "Theories of Organic Chemistry" are good, bringing together many of the newer ideas that do not always find their way into elementary texts. Also scattered throughout the text are clear pictures of many reaction mechanisms which should be helpful to the student. A comprehensive review of recent developments in the chemistry of the

vitamins, hormones, alkaloids, and synthetic polymers is included. All in all, it seems to be a well-rounded teachable book.

A few unfortunate errors, factual and typographical, were allowed to slip through, such as the incorrect statement on page 303 that cyclobutanone has not yet been prepared, and the formula for pantothenic acid on page 648 which is only half there—the betanaline half of the molecule having been entirely omitted. In spite of these and other lesser misprints, the book is a good one, well printed and sturdily bound; the type used is excellent. It can be recommended highly both as a text and as a general reference book.

ARTHUR ROE
University of Illinois

PLANE GEOMETRY, by Howard B. Kingsbury, M.A., *Chairman, Mathematics Department, West Division High School, Milwaukee, Wisconsin,* and R. R. Wallace, M.A., *Administrative Assistant, Wells High School, Chicago, Illinois; Past Chairman, Mathematics Departments, Kelly and Wells High Schools, Chicago, Illinois.* Cloth. xii+484. 2×14×22 cm. 1941. The Bruce Publishing Company, New York. Price $1.68.

The diversity of needs of present day students in high school geometry classes have been well met in this book which contains a wealth of graded interesting exercises; the more difficult of which are marked Honor Work.

The five books of plane geometry have been broken up into twenty-six smaller units called chapters. Wherever possible the geometry is correlated with the pupil's previous knowledge of arithmetic and algebra. The proof of each proposition and problem is preceded by a clearly stated plan. Objective tests are conveniently placed at many points throughout the book. Practical applications of the principles of geometry occur throughout the book.

Careful efforts were taken to follow the recommendations of the National Committee on Mathematics Requirements and the College Entrance Examination Board. Propositions, the proofs of which are required by the latter board are marked with an asterisk. At the end of the book is given a list of two hundred and ten review exercises arranged for efficiency of use.

The topography, pictures, cuts, composition, and binding are good.

JOSEPH J. URBANCEK,
Chicago Teachers College

COLLEGE ALGEBRA, by Harold T. Davis, *Department of Mathematics, Northwestern University.* Cloth. Pages xiii+423. 14.5×23 cm. 1940. Prentice-Hall, Inc., 70 Fifth Avenue, New York, N. Y. Price $2.50.

Professor Davis' book shows how the ideas of modern mathematics can be used to refresh and re-animate the work of such a standard course as that of College Algebra. Such different subjects as statistics, number theory, the history of mathematics and modern research into the concepts of number and infinity as used to illustrate and illuminate the topics discussed.

Nevertheless it must not be thought that the book hops, skips, and jumps over the standard course. The emphasis, as Professor Davis remarks in his preface, is to "provide among other things a systematic drill in operational techniques."

Starting with a review of the fundamentals of algebra—factoring, fractions, exponents, etc.—the book continues with discussions of Logarithms, Progressions, Functional Relationships, Graphing, Linear and Quadratic

Functions, Binomial Theorem, Theory of Investment, Permutations and Combinations, Probability, Elements of Trigonometry, Complex Numbers, Theory of Equations, Determinants, Inequalities, Infinite Series, Statistics, and concludes with a chapter on mathematical recreations and the meaning of mathematics.

B. FRIEDMAN
Wilson Junior College, Chicago

ESSENTIALS OF ALGEBRA, First Course, by Walter W. Hart, *Formerly Associate Professor of Mathematics, School of Education, University of Wisconsin.* Cloth. Pages viii+439. 13×20 cm. 1941. D. C. Heath and Company, 285 Columbus Ave., Boston, Mass. Price $1.28.

This is a worthy member of the long succession of excellent texts by the same author. It contains much new material while retaining all of the features which made his previous algebras successful. The preface states that "its techniques of instruction are those approved by modern educational psychology and by a lifetime of experience of the author as a teacher of and writer of texts for secondary mathematics."

The book begins with a study of statistical graphs. The pupil's interest is caught at the outset with an explanation of how graphs, formulas, tables, equations, positive and negative numbers and indirect measurements were all used in designing and building the San Francisco-Oakland Bay bridge. The formula is used throughout as a unifying strand to furnish the reason for studying symbols, vocabulary and equations. An improved treatment of rounding off numbers is given. A good feature is the use of parallel columns to compare the mental processes used in solving equations with the solution as actually written out. The definition of an identity given is that advocated by the late Dr. E. B. Skinner rather than the less correct one usually found in algebra texts. The method given for translating the English statement of a word-problem directly into the language of algebra is one which the reviewer has found consistently successful.

Ingenious devices for motivation arouse the interest and curiosity of the learner. For example, each chapter begins with a "preview" suggesting the relationship of the new topic to the pupil's experience, together with its place in the history of mathematics, while the adolescent fascination for magic is drawn upon in introducing the solution of simple numerical equations as preparation for performing mind-reading tricks. Simultaneous equations are made vital to the pupil by considering a typical problem of a high school finance committee.

The book closes with a chapter on remedial arithmetic which may be assigned when and where needed. This plan is perhaps not as good as one the author followed in a previous algebra when he distributed this remedial material at the proper places throughout the text. The book abounds with practice examples, differentiated on three levels of ability, with review, cumultive reviews and tests throughout, together with a chapter containing topical reviews, a full year review and a final full year test. This book, attractively bound in scarlet, is well illustrated with line cuts and wax diagrams (the war influence is seen in one or two of the illustrations), and is perhaps the most interestingly written of all the Hart algebras.

GLENN HEWITT
Von Steuben High School
Chicago, Illinois

ESSENTIALS OF ALGEBRA, Second Course, by Walter W. Hart, *Formerly Associate Professor of Mathematics, School of Education, University of*

Wisconsin. Cloth. Pages viii+344. 13×20 cm. 1941. D. C. Heath and Company, 285 Columbus Ave., Boston, Mass. Price $1.32.

This book follows the same general plan used by the author in his companion text, *Essentials of Algebra, First Course*. There is the same motivation by previews and problems meaningful to the learner; correct formulations of definitions, principles and rules; a similar abundance of differentiated examples, reviews, cumulative reviews, diagnostic tests; a final miscellaneous review and a final full year test. The graph is used as a strand throughout to explain concepts and principles.

For the most part whenever the same topic is treated in both of the companion volumes, it is written differently in each, with different practice examples. In some places however, notably in the chapter on quadratic equations, certain pages are practically duplicates of the corresponding pages in the *First Course*, while in other parts of this chapter the only differences in the problems of the two books is a change in the numerical constants. The chapter on logarithms is very good.

GLENN HEWITT

NEW VOCATIONAL MATHEMATICS FOR BOYS, by William H. Dooley, *Principal, Straubenmuller Textile High School, New York City*, and David Kriegel, *in Charge of the Navy Yard Apprentice School for the Board of Education, New York City*. Cloth. Pages xiv+349. 13×20 cm. 1941. D. C. Heath and Company, 285 Columbus Avenue, Boston, Mass. Price $1.64.

This is an entirely new book, being a complete revision of Dooley's *Vocational Mathematics* published in 1915. The material has been completely reorganized and rewritten, some unnecessary topics have been omitted, and several new topics, such as the slide rule, precision instruments and mathematics of the radio, have been introduced. The mathematical teaching is greatly improved; the applications to shop work and machines is brought up to date. The whole text is practical and teachable. There is an abundance of graded exercises and practical problems, with some of the necessary data to be obtained by reading scale drawings. Short cuts in calculation are frequently presented. Without introducing any formal deductive proofs, the authors have combined arithmetic, algebra and elementary trigonometry with plane and solid geometry. Some idea of the scope of the book may be obtained from the following partial list of contents:

Part I: Computation and Measurement. Eight chapters. (Review of arithmetic; formulas; equations; percentage; ratio and proportion; areas of plane figures; volumes and areas of solids; logarithms; slide rule; trigonometry of the right triangle; graphs; tables).

Part II: Carpentering and Building. Two chapters. (Measuring lumber and flooring; excavations; foundations; framing; roofs; stairs; lathing; bricks; concrete; painting; estimating).

Part III: Plumbing and Heating. Two chapters. (Water supply, drainage, water power, heating).

Part IV: Mathematics for Machinists. Eight chapters. (Foundry problems; bolts and screws; precision measuring tools; power transmission; lathes; planers, shapers and drilling machines; milling machines).

Part V: Electricity. Three chapters. (Direct and alternating current; radio mathematics; tables).

This text can be used in either of the first two years of technical high schools, trade or manual training schools, Navy Yard apprentice schools and other schools or classes where shopwork is taught.

GLENN HEWITT

"A knowledge of the past, however imperfect, adds to the attractiveness of the present."—A. C. SEWARD.

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